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OCTOBER 18, 1898.

At the meeting of October 18, 1898, the following com-
munications were made:

THE MINUTE ANATOMY OF THE OBLONGATA AND PONS OF THE CHIMPANZEE (TROGLODYTES NIGER) WITH SPECIAL REFERENCE TO THEIR HOMOLOGIES WITH MAN.

EDWARD WYLLYS TAYLOR.

(*From the Sears Pathological Laboratory of the Harvard Medical School.*)

The study of the anatomy of the anthropoid apes has been
vigorously prosecuted for many years.   Such study has
been directed chiefly toward a better understanding of
gross relations.   Numerous exhaustive discussions have been
published on the central nervous system, dealing with the
surface anatomy of the brain and the arrangement of its
convolutions.*   The chimpanzee has had, perhaps, more
than its share of attention in this regard at the hands
of Marshall (1), Bichoff (2), Beddard (3), Parker (4),

1.   Marshall. Brain of a Young Chimpanzee. Nat. Hist. Review. New
       Series 1, 1861, p. 276.
2.   Bichoff. Sitzungsberichte der Math. Phys. Classe d. K. Bayer. Akad.
       München, 1871, p. 98.
3.   Beddard. Contributions to the Anatomy of the Anthropoid Apes.
       Trans. Zoöl. Soc. 1892–3, xiii. pt. v.
4   Parker. On the Brain of a Chimpanzee. Med. Record, Jan. 1880.

Benham (5), Kukenthal and Ziehen (6), Dwight (7), and others.

While recognizing the great value of such researches, we cannot but feel that they are secondary in importance to a minute study of those finer relations, upon the existence of which the grosser anatomical form must always, in last analysis, depend. There can be no question that the time has come for a painstaking study of fibre systems and cell arrangement, if we are to arrive at any true conception of the fundamental problems underlying the subtle differences between the mental states of man and of his nearest neighbors in the evolutionary scale. Nearly forty years ago Huxley (8) was engaged in a vigorous controversy with Owen regarding certain anatomical points relative to the cerebral structure of man and the apes. Even then Huxley spoke of the difference of opinion as a "preposterous controversy." To us, looking at the matter from a somewhat different point of view, it seems preposterous because so completely unessential to any real determination of questions at issue. Interesting as it may be as a fact, that certain apes have a "posterior lobe, a posterior cornu, and a hippocampus minor" (9), we can, by no stretch of the imagination, see in that a discovery of vital significance. The brain, above all, needs to be studied in its internal relationships. To one who has followed the development of our knowledge of cerebral function it must be evident that the need of the future is to go below the surface, and attack the infinitely difficult problems which the layers of the cerebral cortex and the fibre tracts, with which these layers are so intimately

5. Benham. A Description of the Cerebral Convolutions of the Chimpanzee known as "Sally," with notes on the convolutions of other chimpanzees and of two orangs. Quart. Journ. of Mic. Sc. vol. 37, 1895.

6. Kukenthal and Ziehen. Untersuchungen über die Grosshirnfurchen der Primaten. Jenaische Ztscht. für Naturwissenschaft, 22 Bd. 1 Ht. 1894.

7. Dwight. Notes on the Dissection and Brain of the Chimpanzee "Gumbo." Mem. of Bost. Soc. Nat. Hist. vol. 5, No. 2.

8. Huxley. Man's Place in Nature. pp. 133–138. Appleton edition.

9. Huxley. Loc. cit.

associated, present.   It is only by such study, and by the
determination of the structure of brain substance, that brain
surface becomes, in any sense, significant.   Otherwise we
are dangerously near the much-ridiculed position of the
phrenologist, who attaches a meaning to the merely super-
ficial.

As one looks through the literature on the subject of that,
in many respects, most interesting of the man-like apes,
the chimpanzee, it is striking to note how little has been
attempted toward any detailed study of cerebral structure,
in contrast to the voluminous literature of surface develop-
ment.   The paper of greatest value is by Spitzka (10) on
"The Penduncular Tracts of the Anthropoid Apes," written
in 1879.   The oblongata and pons of the chimpanzee are
particularly considered.   To this paper we shall have re-
peated occasion to refer, especially since, in certain essential
respects, our observations differ from those advanced by
Spitzka.   A later piece of work by Kallius (11) appeared
in 1892, entitled "Ueber die Medulla Spinalis und die
Medulla Oblongata von Troglodytes Niger," in which is
given a detailed description of certain features of the spinal
cord and especially of the oblongata of the chimpanzee.
Waldeyer's (12) monograph on the spinal cord of the
gorilla, although not directly concerning the present work,
should be mentioned as by all means the most complete
investigation we have relative to the minute anatomy of the
anthropoids.

The following investigation must be regarded as prelimi-
nary to future study, which should be directed toward a
better understanding of the anatomy of the cerebrum, and
ultimately of the cortex, in which the final secret of the
differentiation of brain types must lie.

10. Spitzka. The Penduncular Tracts of the Anthropoid Apes.   Jour.
        Nerv. and Mental Dis. vol. 6, 1879, p. 461.   This paper is unfort-
        unately without illustration of any sort.
11. Kallius. Ueber die Medulla Spinalis und die Medulla Oblongata
        von Troglodytes Niger.   Inaugural dissertation. Berlin, 1892.
12. Waldeyer. Das Gorilla-Rückenmark.   Aus d. Abhandl. d. Kgl.
        Preuss. Akad. d. Wissenschaft zu Berlin, 1888.   Berlin, 1889.

The specimen[1] which forms the basis of this paper was taken from a large male chimpanzee known as "Gumbo," ten to twelve years old. The gross anatomy was studied by the aid of the brain belonging to a second chimpanzee of good size. A well-preserved brain of a baboon (probably Cynocephalus hamadryas) served for comparative study of surface relations. The human brain has, naturally, frequently been called into service, especially by way of comparison of its minute structure with that of the closely related brain of the chimpanzee. The present work is confined to the oblongata and pons.

Methods of Preparation. — The specimen was hardened in Müller's fluid and alcohol in the usual way, and imbedded in celloidin. Sections were made from the lowest level of the pyramidal crossing to the region of the quadrigemina from seventy-two levels. Stained with: 1. Weigert haematoxylin (best results with modified copper solution); 2. Pal, modification of Weigert; 3. Ammonio-carmine; 4. Nigrosine; 5. Picric-acid-fuchsin (Van Geison); 6. Carmine-haematoxylin.

In the following account an attempt will be made to describe in some detail the anatomy of the oblongata and pons of the chimpanzee, with reference to the same structures in man. The microscopic study of the sections will be made, as is usual, from below upward. For the sensory tracts such a method leads to no confusion. In speaking of the motor (py. tracts), however, it should be borne in mind, since their physiological course is downward, that the lower part of the crossing is more, properly speaking, the end than the beginning of the motor decussation. This being understood, it will be more convenient to transpose the words "beginning and end" when referring to the motor crossing.

General Description of Gross Anatomy of Oblongata and Pons. — Cranial nerve-roots are identical with those of man as regards their exits from the central mass. The chimpanzee shows a much less marked distinction in the oblongata

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[1] The brain of the same chimpanzee has been studied, and notes upon it published by Dr. Thomas Dwight. See ref. 7. The material was given me for microscopic study by Dr. Wm. T. Councilman.

between the olives and the pyramids than is ordinarily seen in
the human brain.   The olivary eminences are prominent, but
more rounded, and the pyramidal tracts are somewhat flatter
in appearance.   The restiform bodies are well developed,
but less so than in man.   (See description of cross-sections.)
The oblongata is more symmetrically rounded, but gradually
tapers towards the cervical cord.   This latter fact Spitzka
(13) regards as peculiar to man and the chimpanzee.   A
comparison with the oblongata of the baboon shows the
chimpanzee to be distinctly more human-like, and decidedly
more resembling man than the baboon resembles the chim-
panzee.

The *pons* of the chimpanzee is massive, but, relatively,
markedly less so than in man, particularly at its junction
with the bulb.   The trapezoid fibres are concealed.   The
pons, like the oblongata, is flattened ventro-dorsally.   Spitzka
(14) describes the pons as massive, in contrast to other
animals, and only slightly less voluminous than in man.   Our
observation goes to show that the difference is much more
pronounced than Spitzka allows.   Spitzka (15) finds also
the following man-like features in the chimpanzee, not
found in non-anthropoids: 1. Massive prominence of anterior
extremity of pons.   2. Near approach of pons to infundi-
bulum (topographically).   3. Direction of the crura.

Description of Finer Anatomy of Oblongata. — Lowest level
(16): (Region of transition from cord to bulb.) No. 1, serial,
picro-fuchsin prep.

At this level (fig. 1) the appearance of the section re-
sembles, in most respects, that of the human.   A striking
difference is the greater delicacy of the gray matter, taken as
a whole, in the case of the chimpanzee.   The ventral horns
are proportionately smaller.   Kallius (17) speaks of a notice-

13.   Loc. cit., p. 469.
14.   Loc. cit., p. 468.
15.   Loc. cit., p. 470.
16.   The accompanying sketches were traced by means of the "Edinger
        Drawing Apparatus," low power, and are, therefore, in outline,
        exact reproductions of the original sections.
17.   Loc. cit., p. 22.

able preservation upward of the ventral horns and cell groups. The gray matter about the central canal is less in extent;
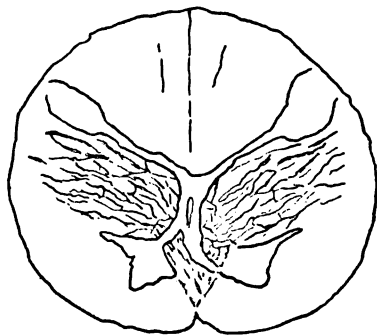
FIG. I. — Chimpanzee.

the gelatinous substance of Rolando less developed ; the formatio reticularis not so well marked. Crossing of the pyramids is beginning at this level, as in the human bulb. Nucleus gracilis appears, as a small amount of gray matter, containing ganglion cells, in the dorso-median column. According to Kallius (18) this nucleus appears lower down than in man. The ascending (more properly descending) root of the fifth nerve is not as yet well marked off from the surrounding tissue, and, as remarked by Spitzka (19), the tip of the dorsal horn approaches very near the periphery. The central canal is represented by an elongated, slit-like opening, exactly as observed by Spitzka (20), except that we find no evidence of diverticula.

Ependymal cells are indistinct. Groups of cells are visible, lying in the ventro-lateral portions of the ventral horns, and also groups of smaller (sensory?) cells, lying mesially at the base of the dorsal horns, corresponding fairly in position with the cells of Stilling's column in the spinal cord. Cells, in addition, are scattered through both ventral and dorsal horns, but these show no tendency to arrangement in groups. The pia mater presents no peculiarity.

At a slightly higher level (No. 2, serial) the same points, as just noted, are observable (carmine prep.). A striking feature and one upon which we desire to lay particular stress is the decidedly greater development of the pyramidal tracts in the chimpanzee, which gives the cross-section an appear-

18. Loc. cit., p. 18.
19. Loc. cit., p. 471.
20. Loc. cit., p. 465.

ance quite different from that of the human oblongata at the same level. In making this statement we take direct issue with Spitzka, who, speaking of the pyramids, writes:

" It is noteworthy, however, that the anterior pyramids are proportionately defective, as compared with those of man;" and again: " The fibres of the motor decussation occupy a much larger area in man, and, as the pyramidal fibres which are still vertical in this altitude are also more voluminous, it results that with the same configuration of the gray substance the vertical (antero-posterior) diameter of the human medulla is relatively greater. Taking the transverse diameter as a standard of 10, the antero-posterior is 9.2 in man, 8.8 in the anthropoid " (21).
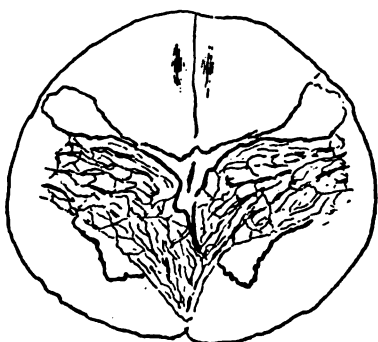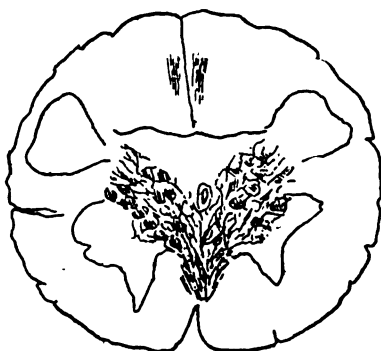
FIG. 2. — Chimpanzee. FIG. 3. — Man.

We are in agreement with the general result of the above measurements, but we do not believe it is due to the small development of the pyramidal tract. Kallius (22) regards the pyramidal tract as, on the whole, like that of man, but makes no special reference to its relative size. In a Pal preparation (plate I., fig. 1) the crossing of the pyramids is well brought out. The contrast in the greater number of fibres to that seen in the human at the same level (fig. 3) is to be especially noted. At this level a few of the fibres have reached the ventral aspect of the bulb.

21. Loc. cit., p. 473.
22. Loc. cit., p. 20.

There is no evidence, at this height, of the formation of the cuneate nucleus.

At heights 3, 4, 5, 6, serial: The development of the oblongata is progressing as one sees it in man, with certain differences: 1. The gray matter bears the same disproportionate relation to the white, already noted. 2. The great development of the py. tracts is apparently at the expense of the gray matter.
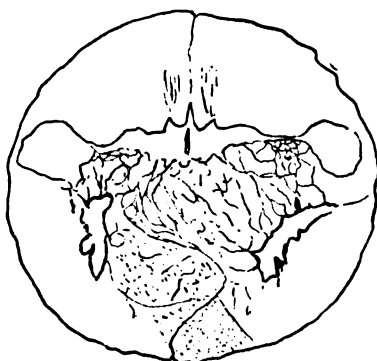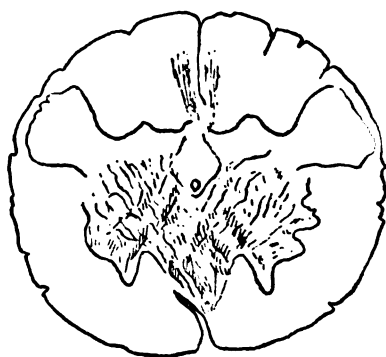
FIG. 4. — Chimpanzee.   FIG. 5. — Man.

At the highest of these levels, viz., sect. 6 (fig. 4), the dorsal horns fall in the same plane with the central canal, which is not the case in a corresponding level from man. (See fig. 5.) Fibres of the root of the fifth nerve are to be distinguished between the substance of Rolando and the periphery of the bulb (nigrosine prep.). In this section a small elevation on the dorsal horns, midway between the central canal and the tips of the horns, is to be seen, containing occasional nerve cells and marking the beginning of the cuneate nucleus.

A Pal preparation shows a wedge-shaped mass of fibres, occupying approximately one-third the area of the section, to be made up solely of crossing motor fibres.

Sections 7–11, serial: The form and position of gray and white matter at these levels is not materially different from that just described. The py. crossing is still the most

prominent feature in the cross-section. A striking appear-
ance is the lack of development even at this height of the
gracile and especially of the cuneate nuclei. The gracile
nuclei are represented by two delicate strands of gray matter,
lying on either side of the dorsal septum. The cuneate
nuclei appear as two slight elevations on the dorsal horns.
We are again in disagreement with Spitzka (23), who finds
the nucleus cuneatus larger in the chimpanzee. Kallius (24),
in general, finds nothing remarkable in the dorsal nuclei, but
considers that the cuneate nucleus has a broader base in the
chimpanzee than in man. To both nuclei in Pal prepara-
tions, numerous fibres of the dorsal columns may be seen
making their way. The position of the central canal, much
dorsal to its place in man at this height, finds a mechanical
explanation in the fact of the enormously developed ven-
trally lying py. tracts. Scattered nerve cells (carmine prep.)
are to be made out, lying at the bases of the remnants of the
ventral horns, being, in all probability, the lower cells of the
hypoglossal (XII) nucleus. Fibres of the hypoglossal nerve
are also visible.

Sections 12, 13, 14. At a level just below the first ap-
pearance of the olivary nucleus the py. crossing is practi-
cally completed, or, more properly speaking, not yet begun.
At approximately this height Spitzka (25) has made some
interesting measurements, in the consideration of which, how-
ever, a very considerable margin of error must be admitted.
Taking the entire area of the oblongata as 1.0000, he finds
that the area of the pyramid in man is .3089, in the chim-
panzee .2384; of the posterior columns, .1032 in man,
.1846 in chimpanzee. Of gelatinous substance of Rolando,
.0647 in man, .1000 in chimpanzee; of cuneate nucleus,
.0283 in man, .0384 in chimpanzee. Spitzka calls attention
to a previous and similar table in his paper, and notes that
the increase of the dorsal columns in the chimpanzee is prob-
ably complementary to deficiency of the chimpanzee's pyra-

23. Loc. cit., p. 473.
24. Loc. cit., p. 18.
25. Loc. cit., p. 473.

mids. It will be evident from the foregoing description that, in spite of figures, we are convinced that such relative areas cannot be universally applicable. Particularly is this true of the py. tracts and the cuneate nuclei, which show converse areas to those stated by Spitzka; viz., the relative area of the pyramids is clearly greater in the chimpanzee than in man, whereas that of the cuneate nuclei is as surely less. This discrepancy is a very marked one, and it may be that we must admit what seems unlikely — that there is a wide normal variation in the tracts of the chimpanzee, possibly dependent upon age. Spitzka, in fact, speaks of a marked difference in his two specimens, one from an adult animal and the other from an infant. Our specimen, however, is to be regarded as an adult, though possibly younger than Spitzka's. Most noticeable in our sections at this height is the shape and generally rudimentary character of the cuneate nucleus (26), leaving the funiculus cuneatus as a broad band of fibres between it and the periphery, unlike the appearance in the human bulb, where the nucleus extends outward, encroaching on the cuneate funiculus, as it receives more and more of its fibres. (See figs. 6 and 7, plates I., II., figs. 2, 3.)
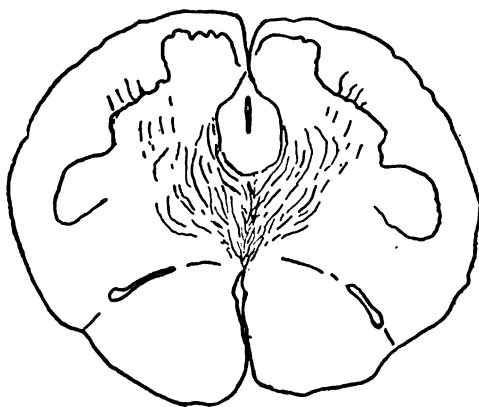
FIG. 6. — Chimpanzee.

The gracile nucleus is also less developed than in the

26. Spitzka, loc. cit., p. 474, makes the statement that a relatively greater number of fibres terminate in the posterior nuclei in the chimpanzee than in man. This seems to us impossible to prove. The poor development of the fillet would argue against such an idea.

human (figs. 6 and 7). The space left between the dorsal horns and the periphery for the root of the fifth (V) nerve is proportionately greater than in man. It is worthy of note that the chimpan-
zee's oblongata at this height is almost exactly circular in outline (27) (plate I., fig. 2), instead of narrowed ven-trally, as is in-variably the case in man. The ex-planation cer-tainly lies in the greater develop-ment of the py. tracts and the delicacy of the

FIG. 7. — Man.

dorsally lying gray matter. In this we may undoubtedly see one of the characteristic peculiarities of the chimpanzee's bulb.
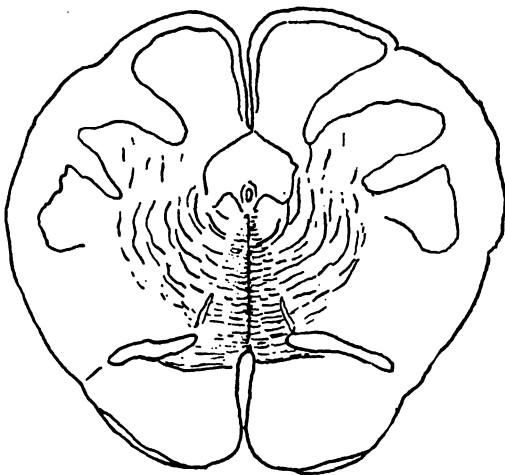
Lower End of Olivary Nuclei ; beginning Sensory Cross-ing ; Formation of the Restiform Body (plate II., fig. 3). — The accessory olives, which first appear, offer nothing note-worthy. The motor decussation is here complete. The sensory crossing — internal arcuate fibres — is beginning with the passage of fibres, especially from the gracile nuclei, across the median raphé, to enter into the formation of the fillet. There is, at this lower level, no essential difference between it and the corresponding formation in man.

The restiform body, or inferior cerebellar peduncle, is now regarded as made up essentially of the following structures :

1. The direct cerebellar tract — uncrossed.
2. Ventral external arcuate fibres — crossed.
3. Dorsal external arcuate fibres — uncrossed.

27. Compare with Spitzka's measurements previously given.

4. Cerebellar-olive tract — crossed.

Of these tracts the first and third may be advantageously studied at this level. Fibres of the cerebellar tracts are visible (Pal prep.), taking their course dorsally to enter into the formation of the inferior cerebellar peduncle. Kallius (28) finds these tracts better developed than in man, a difficult matter to determine in a normal specimen. More noteworthy is a comparatively large bundle of fibres, which leaves the dorsal funiculi on either side and runs uncrossed, about the periphery of the bulb, as dorsal external arcuate fibres, to take their share in the composition of the restiform bodies. These fibres are more distinct than is usually seen in man at a corresponding level. Owing to the slight development of the cuneate nuclei, before alluded to, the funiculus of white matter, representing the dorsal external column of the cord, appears as an elongated band of transversely cut fibres (see fig. 6, plate II., fig. 3), which might easily be mistaken for the restiform body. We are in entire agreement with Spitzka (29) when he says that the restiform formation is not so extensive in the chimpanzee as in man.

Of interest, also, is what appears to be a sudden increase in the number of fibres belonging to the ascending (descending) fifth root (plates I., II.). At lower levels the space allowed between the tip of the dorsal horns and the periphery was rather smaller than in the human; at this level, immediately below, and above until its disappearance in the pons, on the contrary, the space occupied by the root is proportionately much larger than in man. His and later investigations have shown conclusively that the so-called ascending root of the fifth nerve is, in reality, from the point of view of development, a descending root, corresponding probably to the descending branch of the T-shaped division of a posterior spinal nerve. The apparent sudden diminution in size of this root in the chimpanzee may be due to the fact that its terminal fibres are distributed to the gray matter at a higher level than in man. The other alternative is that the position

28. Loc. cit., p. 30.
29. Loc. cit., pp. 478, 485.

of the root in the lower oblongata is not precisely the same as in man. Either hypothesis is incapable of exact demonstration from a study of normal preparations. Spitzka (30) finds the fifth root more crescentic in the chimpanzee; he remarks also its size, but thinks it does not exceed the limit of the human range. We have never seen in a human specimen a root which approaches in size that of the chimpanzee. Kallius (31) speaks merely of a well-developed fifth root.

Sections 14-24. *Opening of Central Canal into Fourth Ventricle* (plate II., fig. 4). — The heights herein included show the further development of the olivary nuclei, the fillet, the restiform bodies, and the sharper definition of the nuclei belonging to the hypoglossal (XII) and the vagus and glossopharyngeal (X, IX) nerves. The olive (figs. 8 and 9) appears as a somewhat simpler structure, so far as its form is concerned, than in man. It is proportionally smaller and the number of its indentations less. Spitzka's work in the olive is particularly complete. In the course of his discussion he says: "In the similarity, nay, almost identity, of the shape, dimensions, and relations of this body, I find one of the strongest resemblances to the human being;" and again: "Its appearance is exactly like that of the human being" (32). This extreme statement is later modified to a certain extent, as it undoubtedly should be.

Remarkable about the fillet is, in the first place, its relatively small size, and, secondly, the peculiar irregularity of its crossing. In relation to this, Spitzka (33) states that fibres of the sensory decussation are remarkably fewer in the ape than in man, due to the fact that less of the posterior column decussates than in man, hence the posterior columns remain larger. If this view be correct we may find an explanation of the better development of the dorsal external arcuate fibres, going to form the restiform bodies, which we have already noted. We have, however, previously called

30.   Loc. cit., p. 481.
31.   Loc. cit., p. 29.
32.   Loc. cit., p. 474.
33.   Loc. cit., pp. 473-4.

attention to Spitzka's claim that a relatively greater number of fibres terminate in the dorsal nuclei in the chimpanzee than in man.   There is a virtual contradiction in these two statements, since our present knowledge goes to show that the fillet is, in great measure, a continuation upward through a secondary neuron of fibres of the dorsal tracts.   Kallius (34) notes the median raphé as more marked in the chimpanzee, a fact which is probably due to the great irregularity of its development rather than to an increase in the number of its component fibres.

The restiform body, through the accession of fibres from the various sources already mentioned, has increased in size, though it has not, as yet, made an appreciable elevation on the postero-lateral aspect of the bulb.   The cuneate funiculus is, at height 23 of the serial, occupied by a number of ganglionic masses, is easily separable from the fibres belonging to the restiform body, and has ceased to have the peculiar appearance so noticeable in sections below.   Nucleus of the (XII) hypoglossal nerve is well marked.   The fibres of the nerve all enter the hilus of the olives, instead of skirting their mesial side, as is usually, though not always, the case in man.   This has been regarded as an ape characteristic   (Spitzka, Kallius).

FIG. 8. — Chimpanzee.

The common vago - glossopharyngeal   nucleus, made up of small cells   (sensory), lies in the same position as in man, corsal and external to the hypoglossal nucleus.   The ascending (35) root (respiratory bundle, solitary fasiculus) of the

34.   Loc. cit., p. 21.
35.   The same applies to this as to the V root.   It is more properly called a "descending" root.

vagus and glossopharyngeal nerves is easily to be made out, as also the cells belonging to the motor nucleus (n. ambiguus). The shape of the cross-section at this level is worthy of note, preserving, as it does, its general circular outline due to the breadth of its anterior position, viz., pyramidal tracts. The olives cause a slight elevation along the periphery as in man. (See figs. 8 and 9.)

Sections 25–31, including the greatest development of the hypoglossal, vago-glossopharyngeal nuclei and nerves, and also of the olivary nuclei.
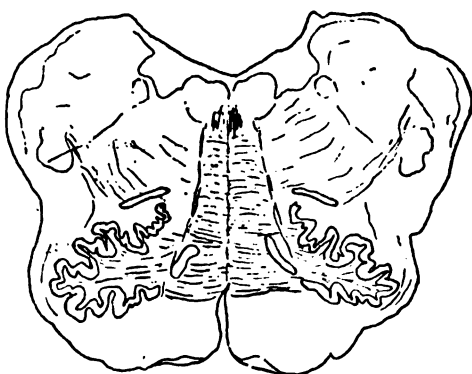
FIG. 9. — Man.

Noticeable, as before remarked, is the invariable entrance of the hypoglossal nerve into the hilus of the olive (plate II., fig. 4). The nucleus of the hypoglossal nerve presents nothing remarkable, except that, perhaps, the small-celled nucleus of Roller has not reached the development usually found in man. Spitzka (36) makes the interesting observation that, in general, the chimpanzee has the same number and arrangement of cells as found in the human being, from which he draws the conclusion that, so far as lower centres are concerned, the innervation of speech does not require more complex arrangements than are found in speechless animals. "The nerve nuclei seem to follow in their mass, not the complexity of the function they subserve, but the size of the area to be innervated from them." It will be generally admitted that the inability of the chimpanzee, for example, to speak is due rather to his failure to form abstract ideas than to any defect in the mechanism of speech production.

36. Loc. cit., p. 481.

The various elements of the vago-glossopharyngeal nerves 37) and nuclei may, for the most part, be made out with great clearness. Especially is this true of the central end of the nerve, which may, in suitable (Pal) sections, be traced to its crossing at the raphé, in the neighborhood of the hypoglossal nucleus. Fibres from the motor nucleus (n. ambiguus) may be followed without difficulty to their junction with the main sensory portion of the nerve. The descending root of the vagus and glossopharyngeal nerve is certainly no more prominent than in man, in distinction from the similar root of the fifth nerve.

The descending root of the fifth nerve remains disproportionately large; it is broken up somewhat by the passage through it of vago-glossopharyngeal and arcuate fibres, the latter proceeding from the now well-developed cuneate nuclei of the dorsal columns, as well as by fibres of the cerebellar olive tract, at this height well formed.

The restiform bodies offer no anatomical peculiarity, excepting their small size.

The external ventral arcuate fibres, of which we have hitherto deferred speaking, form a decidedly smaller tract than is ordinarily seen in man. Especially to be noted is the fact that the nucleus arciformis, so prominent a feature in most human oblongatas, is lacking in the case of the chimpanzee studied (figs. 6, 8; plates I., II., figs. 3, 4, 5). This, doubtless, stands in direct relation to the insignificance of the ventral arcuate fibres. Both Spitzka (38) and Kallius (39) have made a practically identical observation, excepting that they speak of a rudimentary condition of the nucleus arciformis. The fewness of the fibres is unquestioned.

From this point to the region of the transition of the oblongata to the pons little need be said by way of descrip-

37. Müller is able to distinguish the IX from the X nerve in the chimpanzee by the fineness of the fibres of the former nerve. Müller. Zur Anatomie des Chimpanzegehirns, Arch. f. Anthropol. Bd. xvii. 1887–8, p. 173.
38. Loc. cit., p. 482.
39. Loc. cit., p. 23.

tion. The crossing of the fibres of the cerebellar-olive tracts
to olives of opposite sides is easily distinguished. Points
already noticed which persist in this region are, prominence
of py. tracts; fewness of ventral arcuate fibres; large size
of V root; simplicity of fillet; lack of development of resti-
form body. At this level the median raphé presents two
distinct bands of fibres which run toward the ventral aspect
of the bulb, and are partially continuous with ventral arcuate
fibres. These bundles are parallel to each other, and at
some distance from the raphé proper, although they are to be
regarded as forming a part of it. A similar structure may
be seen in man, though much less clearly marked. The
olives show a decided decrease in volume, and are less devel-
oped than in man at the same height. Many fibres of the
pyramidal tracts have ceased to run in a distinctly vertical
course, and the cross-section therefore shows an irregularity
of arrangement in these tracts. Certain of the arcuate fibres
may be seen running directly through the pyramids, instead
of taking their more usual way around the periphery.

It is worthy of remark that the area of the chimpanzee's
bulb at the level we are considering is much less than that
of the average human bulb, whereas at lower levels — *e.g.*,
py. crossing — the relative difference in size is insignificant.

The points of special anatomical interest to which the fore-
going study of the oblongata leads are as follows:

1. *The great development of the motor tracts.*
2. *The peculiar conformation of gray matter.*
   a. The high level at which the nucleus cuneatus first
reaches its complete form.
   b. The comparative simplicity of the olives.
3. *The irregular character of the sensory crossing, and the
smallness of the fillet.*
4. *The fewness of the external ventral arcuate fibres, and
the absence of the nucleus arciformis.*
5. *The large size of the descending root of the fifth (V)
nerve, at upper levels of the bulb.*
6. *The imperfect development of the restiform body.*

PONS.

Sect. 39, serial. *Transition to pons and region of the eighth (VIII) nerve.*

At its transition to the pons, the oblongata has an outline modified by the facts that the restiform bodies are smaller, the olivary eminences somewhat less prominent, and the pyramidal tracts much more developed than in man. The transition itself takes place in an entirely analogous way. The pyramidal tracts are forced from their position at the periphery by intervening fibres of the pons. The number of
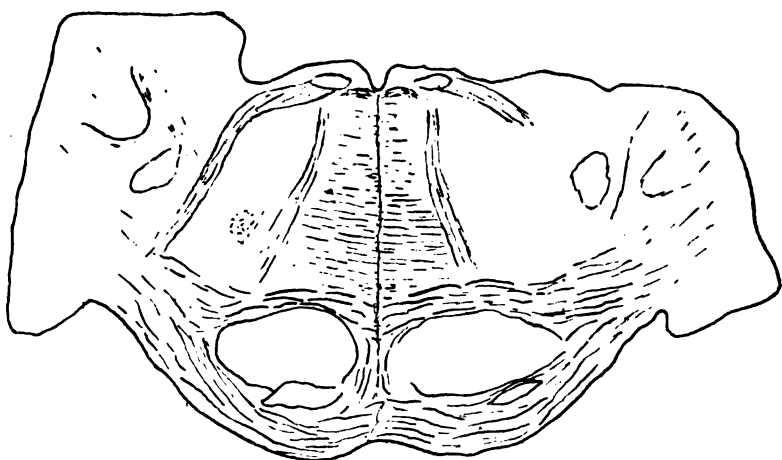
FIG. 10. — Chimpanzee.

these fibres is markedly fewer than in man, but not, as stated by Spitzka (40), in the proportion of 1 to 3 or 4. The fewness of the pontine fibres is, however, undoubtedly to be regarded as the most characteristic feature of the chimpanzee's pons, and the one which chiefly gives to this segment of the nervous system its peculiar anatomical conformation. This fewness of the pons fibres seems to us constant throughout the entire pons, in which again we do not agree with Spitzka, who finds their number varying within wide limits

40.   Loc. cit., p. 482.

from below upward. The trapezoid fibres are well developed, but completely concealed.

The eighth (VIII) nerve offers nothing noteworthy. Its arrangement is like that in man. In the sections studied, striæ acusticæ are not visible, often so prominent a feature in man. It is a fair assumption that they are much less developed in the chimpanzee.

Region of facial (VII) nerve. At this height (see fig. 10) the resemblance to the human section is striking. The relations of the seventh (VII) and sixth (VI) nerves are exactly as in man. Pyramidal tracts are relatively more prominent, and pontine fibres fewer, especially those dorsal to the pyramidal tracts.

The root of the fifth (V) nerve appears as an inverted-comma-shaped mass of fibres in the lower pons. Fibres from the dorsal nucleus of the eighth nerve pass lateral to it; slightly higher it becomes somewhat broken up by various fibres (VIII?) passing through it. Still higher (section 52, serial) its identity is lost as it turns to pass out, with the motor nucleus on its mesial side, as the sensory root of the fifth nerve (41). The further anatomy of the fifth nerve requires no special mention.

The fillet occupies the same relative position as in man, a difference being that owing to the fewness of the pons fibres it lies nearer the centre of the cross-section, instead of being pushed far dorsally, as is the case in man. In the upper pons the division into mesial and lateral fillets is well marked, and the relation to the quadrigemina is the same as in man. (See fig. 11.) The relatively large size of the fillets in the chimpanzee is, no doubt, due to the deficiency of the pons formation rather than to an absolute difference in the tracts themselves.

The motor tracts, in their course through the pons, are massive, as we should expect from their conformation in the oblongata. A most noticeable feature is that they are nowhere broken into and separated into discrete bundles to

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41. This description, if convenient, is inaccurate, since the sensory root originates in the Gasserian ganglion and passes into the pons.

anything like the degree one finds in man. This is, no doubt, due chiefly to the fewness of the transverse fibres. These fibres are especially lacking in the region dorsal to the pyramids.

The middle cerebellar peduncle is less massive than in man, which is entirely in accord with the observations already made respecting the pontine fibres. The superior peduncle of the cerebellum, which appears in the upper series of
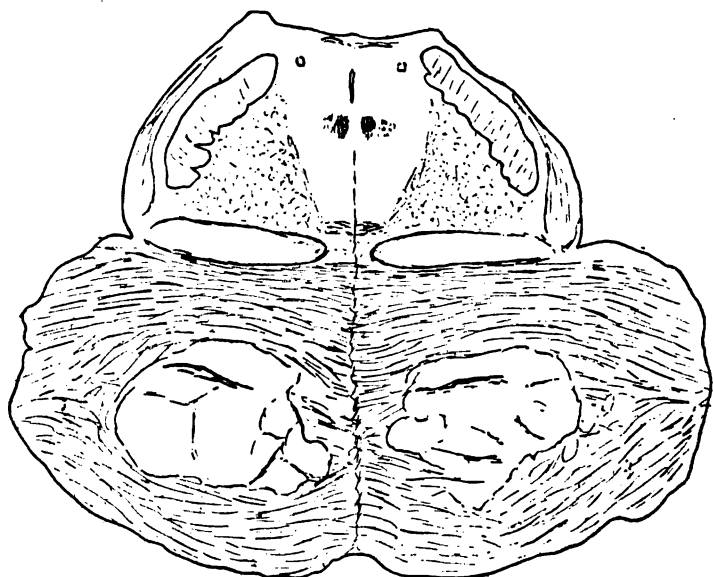
FIG. 11. — Chimpanzee.

sections, is more delicate and more broken into by bits of gray matter than in man.

The posterior longitudinal fasciculus is a much more indefinite structure in the chimpanzee than in man. At upper levels of the pons it is clearly to be made out, but it becomes rapidly indistinct when traced downward.

The transition to the quadrigeminal region takes place as in the human being. Noticeable are the facts that the aqueduct of Sylvius is a narrow slit rather than a patent triangular opening, as seen in man; that the whole dorsal

portion (tegmental region at higher levels) is relatively much more prominent than in man; and finally that the decussation of the superior peduncles is less conspicuous.

Further details of this region do not concern the present work.

Noteworthy anatomical features of the pons are:

1. *The preservation of the identity of the pyramidal tracts.*
2. *The fewness of the essential fibres of the pons.*
3. *The greater relative development of the dorsal portions.*
4. *The insignificance of the posterior longitudinal fasciculus.*

Conclusions. — The foregoing study of the oblongata and pons of the chimpanzee derives its interest from the striking resemblances to the human being no less than from the manifold differences in finer structure.

Regarding, as we do, many of the fibre tracts in the pons and oblongata as cortical projection systems, we find at once an anatomical justification for many of the peculiarities we have described. The great development of the pyramidal tract stands in definite relation to the well-formed motor convolutions bordering the fissure of Rolando. The deficiency of pons fibres is, no doubt, associated with the comparatively small development of those portions of the brain from which those fibres are derived, and, in general, we may see represented in the pons and oblongata much of the anatomy of the cerebral cortex. Further analysis along these lines is to be. desired, and would, no doubt, lead to a much clearer conception of the architecture of the brain of the higher apes than we, at present, possess. There can be no question from our study as well as from that which has gone before that the similarity between the brain of the anthropoid apes and of man is one of the most striking and interesting facts of which we have knowledge.

Spitzka (42) writes: " In the development of the nucleus dentatus of the olive, in the preponderance of the pes pedunculi, the vertical pons fibres and the anterior pyramids, man and the anthropoids *together* possess characters separating

42.   Loc. cit., p. 485.

them from all other animals. In the reduction of the molecular gray matter, by which the area of the strands connected with higher automatic and intellectual centres is inversely increased, we notice another striking parallelism between the two. . . . If we were to represent the average development of the higher (hemispheric and cerebellar) tracts of the human being as 100, the chimpanzee would rank about 75, the cebus at 25, the dog at 7½."

DESCRIPTION OF PLATES: OBLONGATA, CHIMPANZEE.[1]

PLATE I.

FIG. 1. — Stain, Pal. Section through lower portion of py. crossing. Important points are: prominence of fibres of py. tracts; delicacy of gray matter, and position and size of tips of dorsal horns.

FIG. 2. — Stain, Pal. Section slightly above py. crossing. Noteworthy are size of pyramidal tracts; irregularity and relative fewness of fibres of sensory decussation; prominence of descending root of fifth nerve; imperfect formation of cuneate nuclei; absence of arciform nuclei.

PLATE II.

FIG. 3. — Stain, Pal. Section slightly higher than fig. 2. Lower portion of olivary nuclei. Same peculiarities as in fig. 2. Smallness of fillet and excessive development of descending fifth root are striking.

FIG. 4. — Stain, Pal. Section through mid-oblongata, region of hypoglossal and glossopharyngeal nerve nuclei, and lower portion of restiform body. Hypoglossal and vago-glossopharyngeal nerves may be seen. Delicacy of fillet; prominence of pyramids; development of olives; fewness of internal arcuate fibres and especially of external ventral arcuate fibres; absence of arciform nuclei are noteworthy.

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[1] The photographs were made by Mr. L. S. Brown, Pathological Laboratory, Mass. General Hospital.
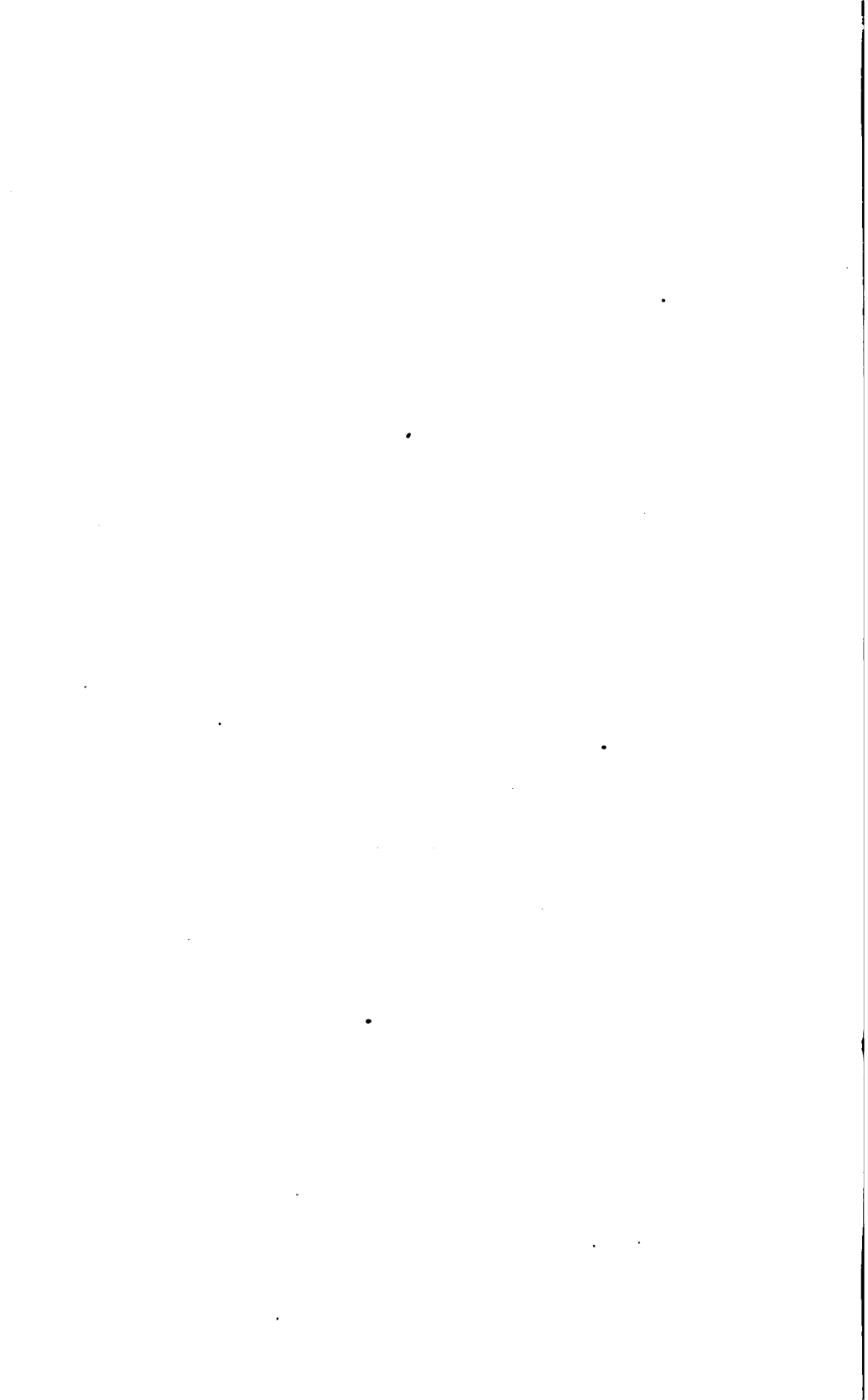
PLATE I.
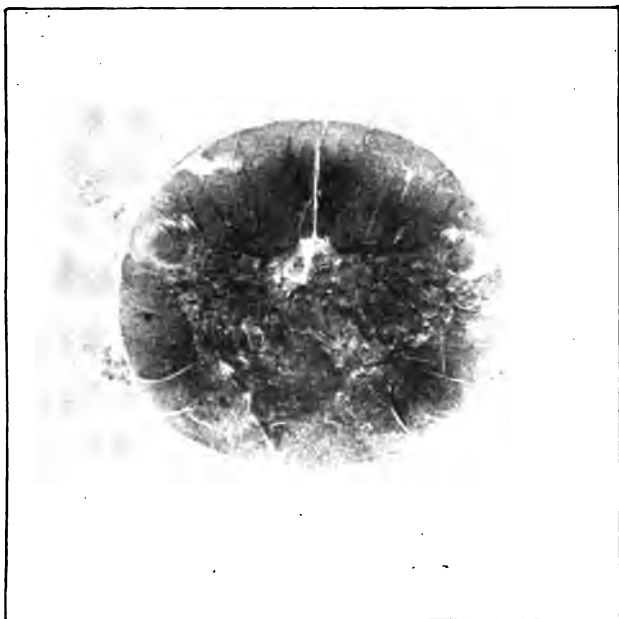
FIG. 1. — Oblongata, Chimpanzee: Objective, 70 mm. Zeiss. No ocular. Magnification 5 +.

FIG. 2. — Same: Objective, 70 mm. Zeiss. No ocular. Magnification 5 +.

PLATE II.

FIG. 3. — Same. Objective, 70 mm. Zeiss. No ocular. Magnification
5 +.
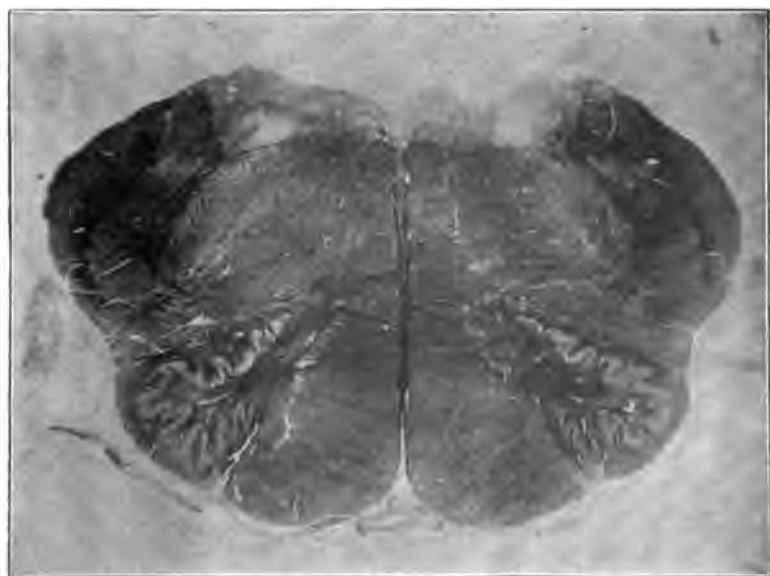
FIG. 4. — Same. Objective, 70 mm. Zeiss. No ocular. Magnification
5 +.

THE LESIONS IN THE CORD FROM A CASE OF FRIEDREICH'S
OR HEREDITARY ATAXIA.

(PRELIMINARY REPORT.)

OSCAR RICHARDSON.

(*Pathological Laboratory, Massachusetts General Hospital.*)

For the opportunity of performing this autopsy the laboratory is indebted to Dr. William M. Conant, who kindly called our attention to the case and arranged the conditions so that we could do it. We are also indebted to Dr. L. M. Palmer, the family physician, through whose perseverance the consent for the examination was obtained, and who was of the greatest assistance to us at the autopsy. The history of the case is an interesting one. In 1885 (in the " Boston Medical and Surgical Journal" of October 15, page 361, vol. 113) Dr. W. Everett Smith reported a case of hereditary ataxia, with autopsy, and stated that it was one of six cases in the same family, a father and five daughters. This case of Smith's is recorded in the literature on hereditary ataxia as a very remarkable and typical example of the disease. Dr. Smith, in this same article, described with considerable care the appearance and general condition of the oldest of the daughters, who was then living, and writes that she represented the completest development of the disease as it occurred in this series of cases. It was this daughter who came to autopsy in October, 1897, and whose spinal-cord lesions I am to speak about very briefly this evening. The following conditions of the body were apparent: The limbs were wasted, the feet fixed in the position of equino-varus, and there was marked spinal curvature. The spinal cord was slender and atrophied in appearance. The normal morphology of cervical and lumbar enlargements was quite wanting, the lumbar being nearer normal than the cervical. Brain and meninges not remarkable. The medulla rather small. The viscera were given a brief inspection, and no lesions were observed. The cord and brain were placed in formalin, and small sections from them were placed directly

in alcohol for Nissl's stain. The sections from which the lantern-slides are made, excepting the neuroglia sections, were hardened by Weigert's quick method and stained by Pal's modification of Weigert's sheath stain. The neuroglia sections were hardened and stained after Mallory's method. The cord presents at all levels under the microscope an irregular mass of indifferent-shaped cells in the situation of the central canal. These cells appear to string out somewhat into the surrounding gray matter. In the lumbar region the columns of Goll and Burdach are markedly degenerated.

In the column of Burdach in its lower portion, on each side and next to the gray matter, is a small patch of tissue which takes the stain and contains a few apparently healthy nerve fibres. The zones around the posterior root fibres as they enter the cord are also less markedly degenerated than other portions of the posterior columns. The crossed pyramidal tracts are distinctly degenerated, but not so marked as in the column of Goll. The posterior roots show degeneration; the anterior roots do not. We find in the thoracic region that the columns of Goll and Burdach are markedly degenerated, and show similar patches to those in the posterior columns of the lumbar region, where the degeneration seems to have been resisted more successfully. There is a distinct sweep of degeneration, including the crossed pyramidals, and a well-marked margin of degeneration in the situation of the direct cerebellar tract. There is a margin of degeneration on one side of the anterior fissure in the situation of the direct pyramidal tract. The posterior and anterior roots show no degeneration. The cervical region presents the columns of Goll and Burdach in nearly complete degeneration, excepting the zones around the entering posterior roots, which as in the previous sections seem to have withstood the degeneration better than other places in these columns. There is a large area of degeneration well marked, and including the crossed pyramidal and the direct cerebellar tracts, and possibly just touching Gower's tract. In the situation of the direct pyramidal tract, on one side of the anterior tissue, is a

margin of degeneration. The anterior and posterior roots show no degeneration. In the medulla there is a marked degeneration in the situation of the anterior and posterior pyramids, and this is apparent at all levels.

The striking lesions in the cord and medulla are thus seen to be a continuous and symmetrical degeneration in the great sensory and motor tracts. This degeneration we find to be due to the proliferation of the neuroglia, a pure neuroglia sclerosis. A section from any place in the degenerated tracts stained by Mallory's method presents the following characteristics under the microscope: *Longitudinal Section* — instead of a mass of nerve fibres running up and down the section, we see long, wavy, hair-like masses which under higher power are seen to be neuroglia fibres. This tissue in the areas of marked degeneration has occupied the place of the nerve fibres to such an extent that in some fields it is difficult to find a single nerve fibre, either normal or degenerated. In other fields a nerve fibre or two is to be seen showing in the midst of the neuroglia fibres. *Cross-Section* — shows the neuroglia fibres end on, with a few scattered nerve fibres dotted here and there through the sections. In places there are whorl-like masses of neuroglia, which are probably due to the section running parallel in these places to the turn in the wavy fibres. Great numbers of corpora amylacea are present in all of the sections, and no change in the blood vessels is seen.

DESCRIPTION OF PLATES.

PLATE I.

FIG. 1. — Spinal cord. Lumbar region. Pal's stain. Zeiss obj. 70 ᵐᵐ. No ocular. Marked degeneration in the situation of the posterior columns and the crossed pyramidal tracts. Posterior roots degenerated.

FIG. 2. — Spinal cord. Thoracic region. Pal's stain. Zeiss obj. 70 ᵐᵐ. No ocular. Marked degeneration of the posterior columns, the crossed pyramidal tracts, the direct cerebellar tracts, and slight degeneration direct pyramidal tract. Posterior roots normal.

PLATE II.

FIG. 3. — Spinal cord. Cervical region. Pal's stain. Zeiss obj. 70 ᵐᵐ. No ocular. Marked degeneration of the posterior columns, the crossed pyramidal tracts, the direct cerebellar tracts, and slight degeneration direct pyramidal tract. Posterior roots normal.

FIG. 4. — Spinal cord. Region first cervical nerve. Pal's stain. Zeiss obj. 70 ᵐᵐ. No ocular. Marked degeneration of the same columns and tracts as in Fig. 3, only the degeneration in the direct pyramidal tract is much more marked.

PLATE III.

FIG. 5. — Spinal cord. Neuroglia. Longitudinal section from degenerated area posterior columns. Hardened and stained after Mallory's method. Zeiss obj. 2 ᵐᵐ. No. 4 projection ocular. The wavy character of the neuroglia fibres shows well. Near the centre the remains of two or three nerve fibres are seen.

FIG. 6. — Cross section same situation as Fig. 5. Same obj. and stain. Corpora amylacea near the edge and nearer the centre, and below a cross section of a nerve fibre shows well.

PLATE I.

FIG. 1. — Spinal cord.   Lumbar region.
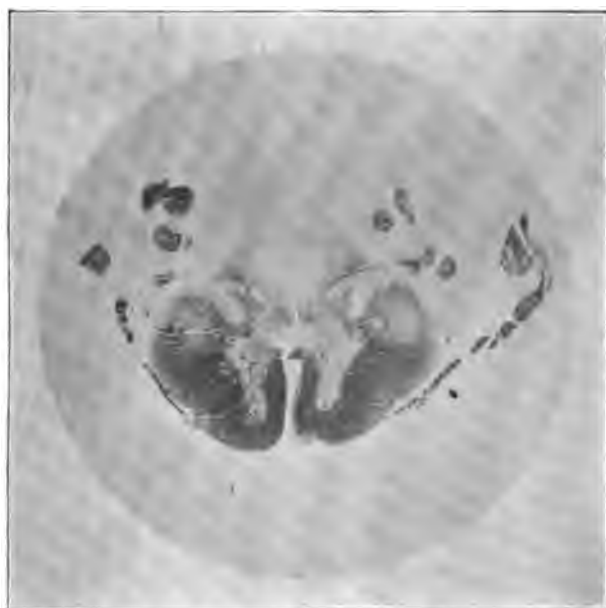
FIG. 2. — Spinal cord.   Thoracic region.
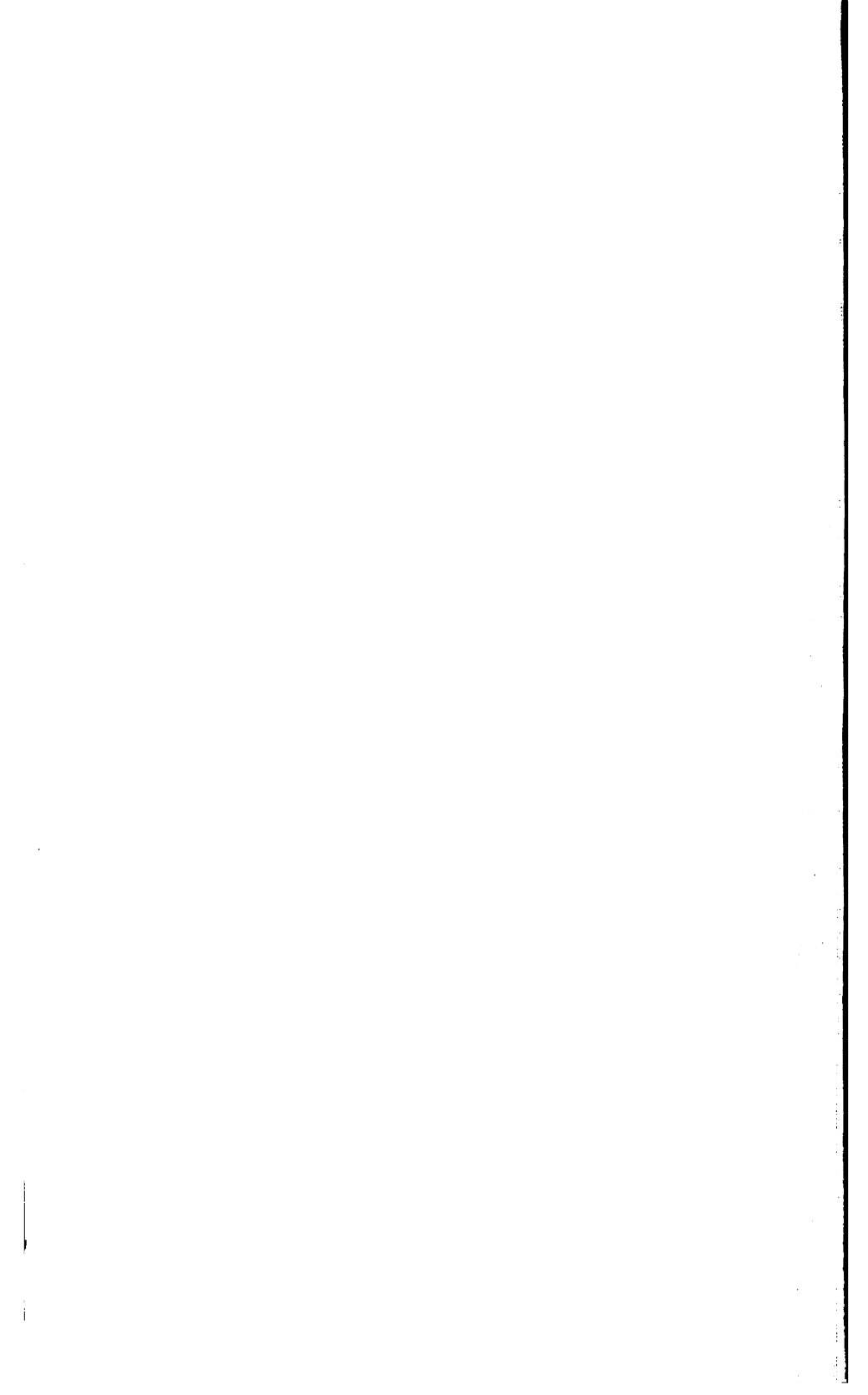
PLATE II.

FIG. 3. — Spinal cord. Cervical region.
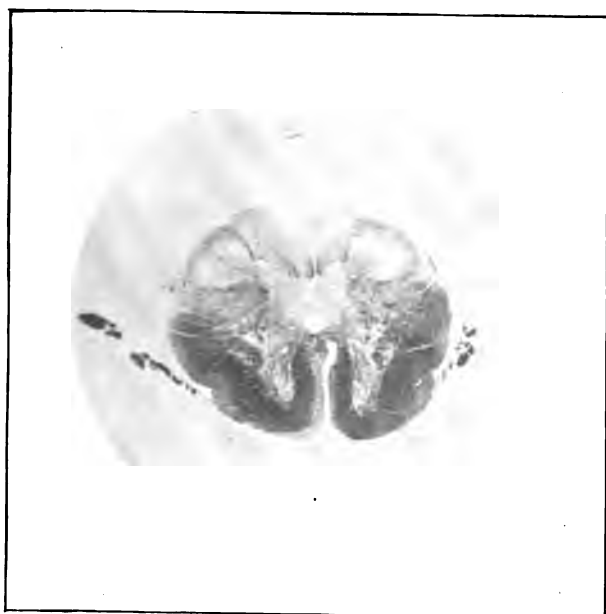
FIG. 4. — Spinal cord. Region first cervical nerve.
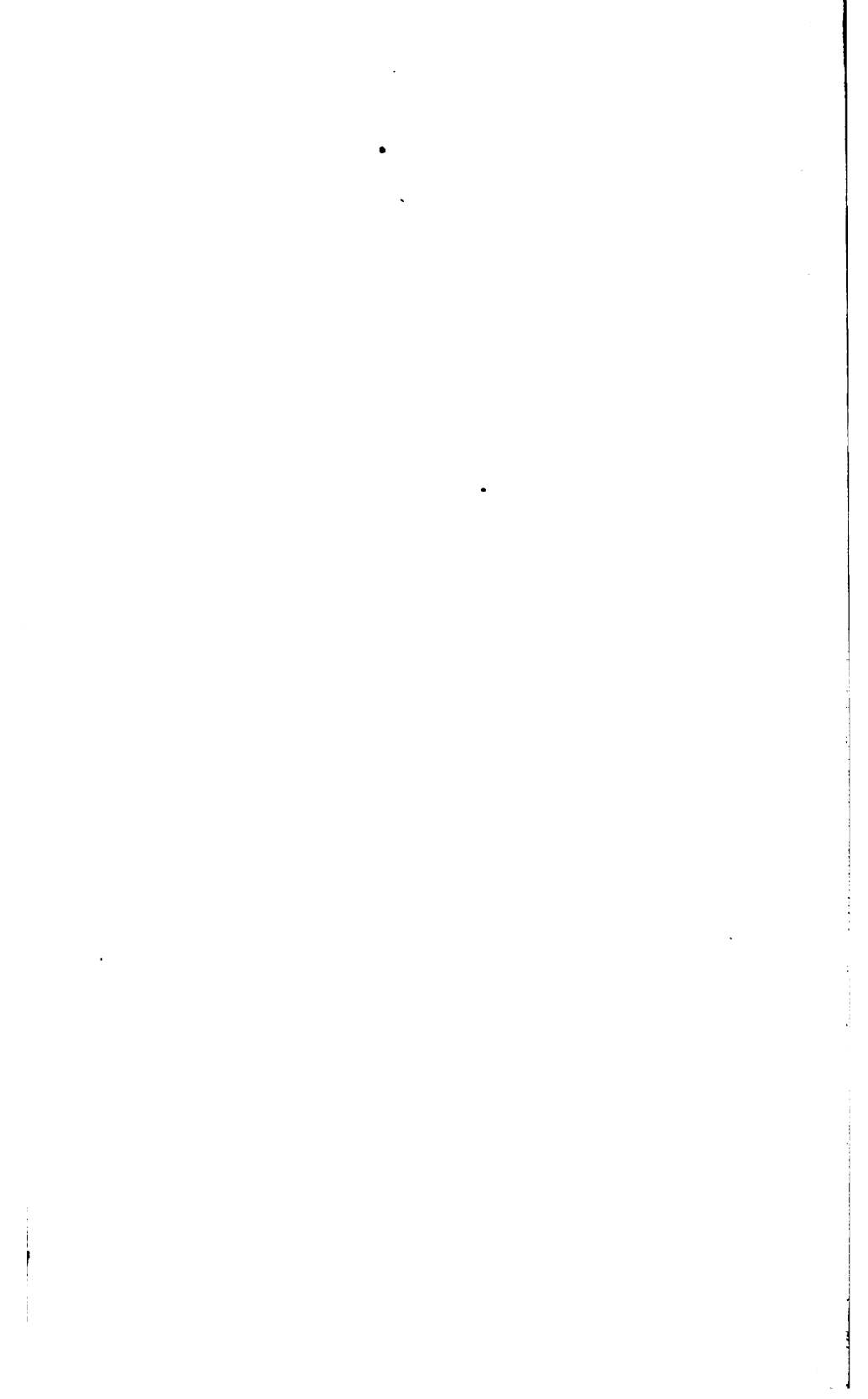
PLATE III.
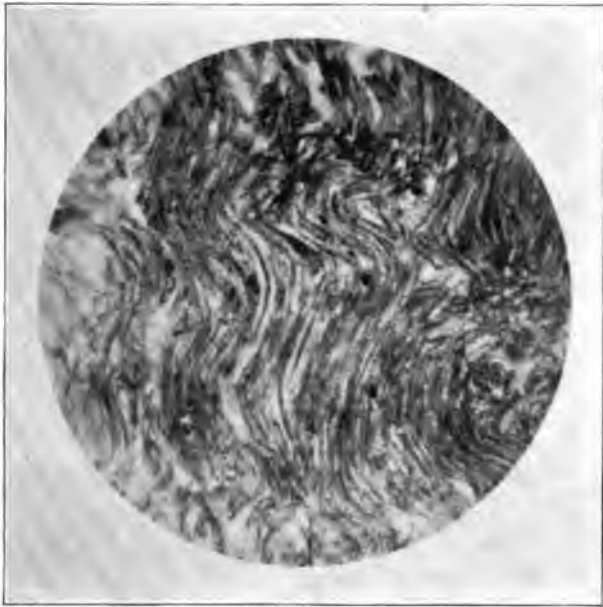
FIG. 5. — Spinal cord.   Neuroglia.
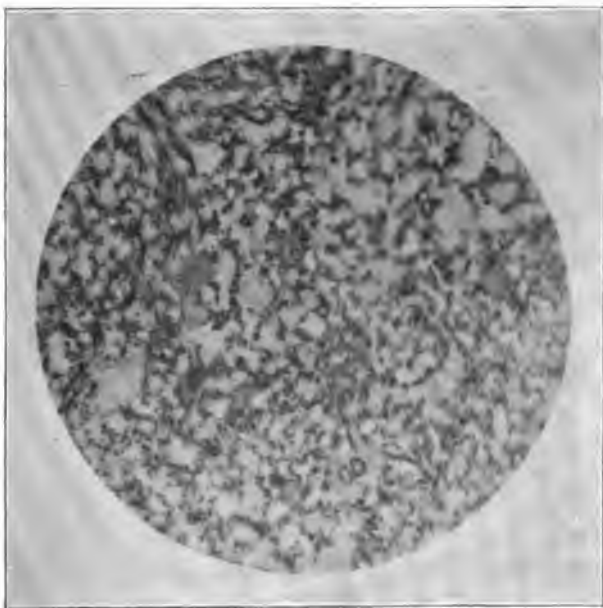
FIG. 6. — Cross section.   Same situation as Fig. 5.
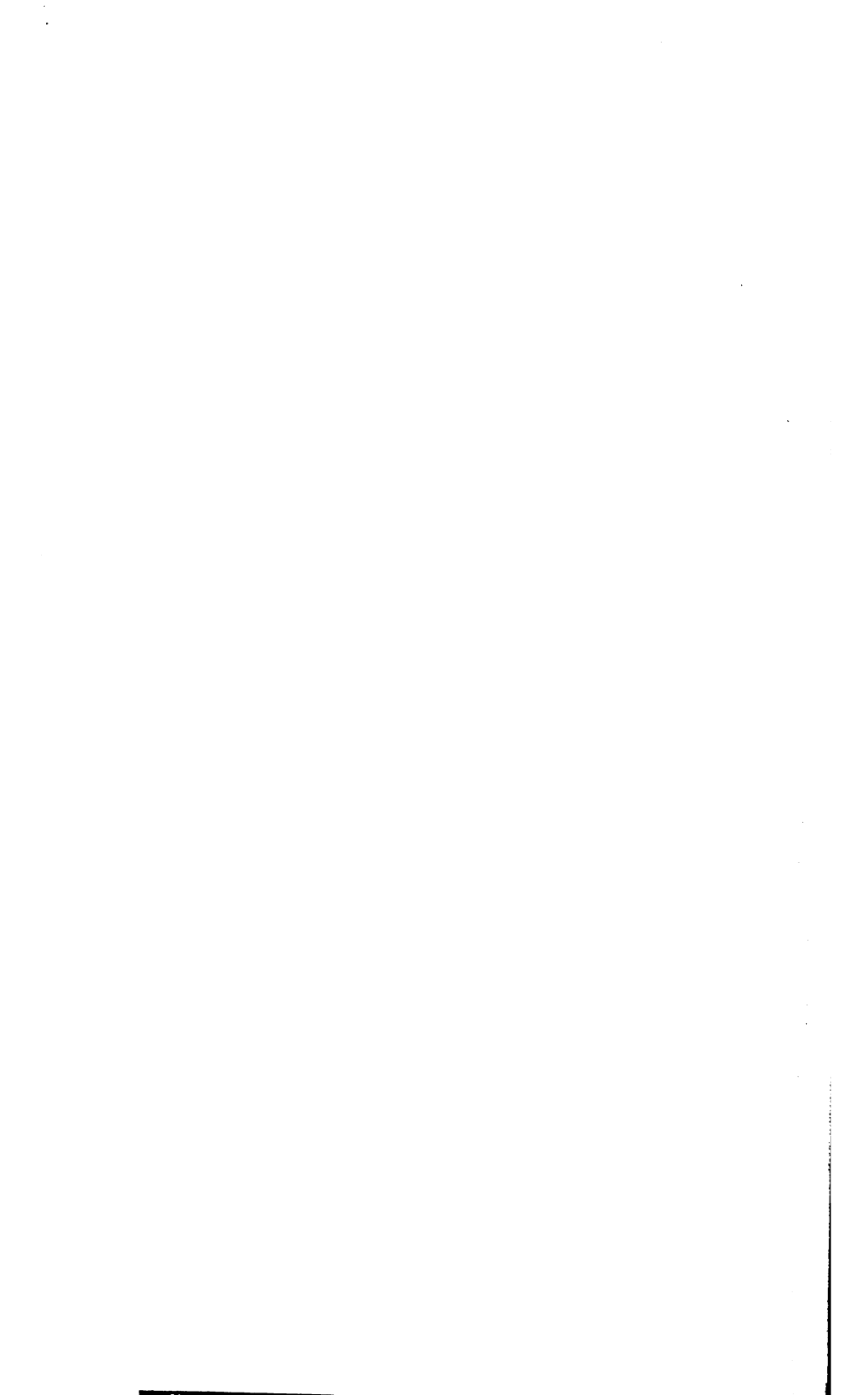
ON THE VALUE OF UROTROPIN AS AN URINARY ANTISEPTIC
WITH ESPECIAL REFERENCE TO ITS USE IN TYPHOID
FEVER.

MARK WYMAN RICHARDSON, M.D.

(*From the Pathological Laboratory of the Massachusetts General Hospital.*)

At a meeting of the Society held Nov. 16, 1897 (JOURNAL, vol. II., p. 21), the writer presented a paper entitled "Upon the Presence of the Typhoid Bacillus in the Urine," and, as the result of his observations, drew the following conclusions :

(1) Typhoid bacilli were demonstrated in the urine of 9 out of 38 cases of typhoid fever.

(2) The bacilli when demonstrated were always present in large numbers, and in practically pure culture.

(3) The bacilli appeared first in the later stages of the disease, and persisted, in the great majority of cases, far into convalescence.   The urines of typhoid patients should, therefore, not only be rigorously disinfected during the disease, but should also be carefully supervised during convalescence.

(4) The typhoid bacilli were practically always associated with albuminuria and the presence of renal casts.   On the other hand, urines containing considerable amounts of albumen, and casts in large numbers, often showed no typhoid bacilli.

(5) Irrigation of the bladder with antiseptic solutions offers a possible means for removing permanently the bacilli from the urine.

The writer has now to report the results of further bacteriological investigation of the urine in typhoid fever, undertaken especially to find, if possible, a method of treatment which should insure the speedy elimination of the typhoid organisms from the infected urines.

In the previous series of investigations a single case was treated with intravesical irrigation.   Solutions of boracic acid 5% proved of no effect.   Solutions of corrosive sublimate (1 :7000) removed the bacilli permanently.

Irrigation, however, with its necessary catheterization, was not a method of treatment easily applicable.   It was deter-

mined, therefore, to try the effect of the internal administration of the so-called urinary antiseptics, — salol, benzonaphthol, resorcin, etc., — in the hope that similar results might be obtained by their use.

The present series includes 66 cases of typhoid fever, and 175 specimens of urine have been examined.

Out of the 66 cases 14 showed the presence of bacilli in the urine. Eleven cases only were submitted to treatment.

Two cases were treated with salol alone. One of these received 30 grains of salol daily for 13 days, with no apparent effect on the bacilli. The other case received a similar dose for 9 days. After 180 grains of the drug had been taken the organisms had disappeared.

In a third case salol was given for a week in daily doses of 30 grains, with no effect. Urotropin was then substituted in a daily dose of 30 grains. After 60 grains of the drug had been given no more typhoid bacilli could be found.

The remaining 8 cases received urotropin alone, always in doses of 10 grains three times daily.

In no case did 90 grains of the drug fail to remove the bacilli — at least temporarily — from the urine. Three cases were followed for 13, 14, and 17 days respectively after the administration of urotropin was stopped, and the bacilli had not reappeared. Three cases were not followed subsequently to the cessation of treatment, so it cannot be said whether or not the organisms returned in those cases.

Two cases showed a reappearance of the organisms. This can be explained in the one case by the fact that the treatment was continued only three days. In the other case there was a marked cystitis, and it is very probable that such a complication makes the elimination of the bacilli much more difficult. Both these cases are still under observation.

We must conclude therefore that: (1) As a remedy for the presence of typhoid bacilli in the urine, salol is much inferior to urotropin. (2) In the great majority of cases, urotropin given for a week in daily doses of 30 grains will remove typhoid bacilli permanently from the urine. When cystitis is present, however, the outlook is not so certain, and treatment must be continued longer.

DURHAM'S METHOD FOR DEMONSTRATING THE PRODUCTION
OF GAS BY BACTERIA.

C. G. PAGE, M.D.

Mr. Herbert E. Durham, of the Pathological Laboratory of
the University of Cambridge, England, writing in the "British
Medical Journal" for May 28, 1898 (p. 1387), describes "a
simple method for demonstrating the production of gas by
bacteria."

The apparatus consists of a large test-tube with a small
one inverted within it. The tube is plugged, sterilized, and
filled with an amount of bouillon equal to twice the capac-
ity of the inner tube. After the first sterilization in the steam
sterilizer there remains only a small bubble of air in the inner
tube. With the second or third steaming the remaining air
is entirely driven out. By using steam under pressure in the
autoclave the air may be all driven out in one sterilization.
The inner tube may also be filled by boiling in a vacuum at
a low heat if the culture medium is injured by a temperature
of 100 degrees C.

The inoculation is easily made if one is careful not to
incline the tube too much.

When the bouillon contains sugar, gas is formed at the
temperature of the incubator, if some gas-producing organism,
as the colon bacillus, has been inoculated.

The advantages of this form of apparatus over the fermen-
tation tube, or the simple U tube with closed end, are obvious.
It is much cheaper and more easily cleaned.

The method of testing for gas production with sugar
bouillon and closed tube is much more convenient and accu-
rate than that of using stab or shake cultivation in agar or
gelatine.

When necessary to test the reaction of the fluid in the inner
tube after a culture has been growing for a time, it is not
difficult to draw off the outer fluid with a fine pipette con-

nected with a rubber tube and glass mouthpiece. When
the last of the outer fluid has been withdrawn, tipping the
tube releases the inner fluid. In cases where some gas has
formed it may be necessary to withdraw the fluid before tak-
ing the tube out of the incubator, as sudden cooling might
contract the gas and draw some of the outer fluid into the
inner tube.

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on November 15, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

HAROLD C. ERNST, M.D.,

Harvard Medical School,

688 Boylston Street,

Boston, Massachusetts, U.S.A.
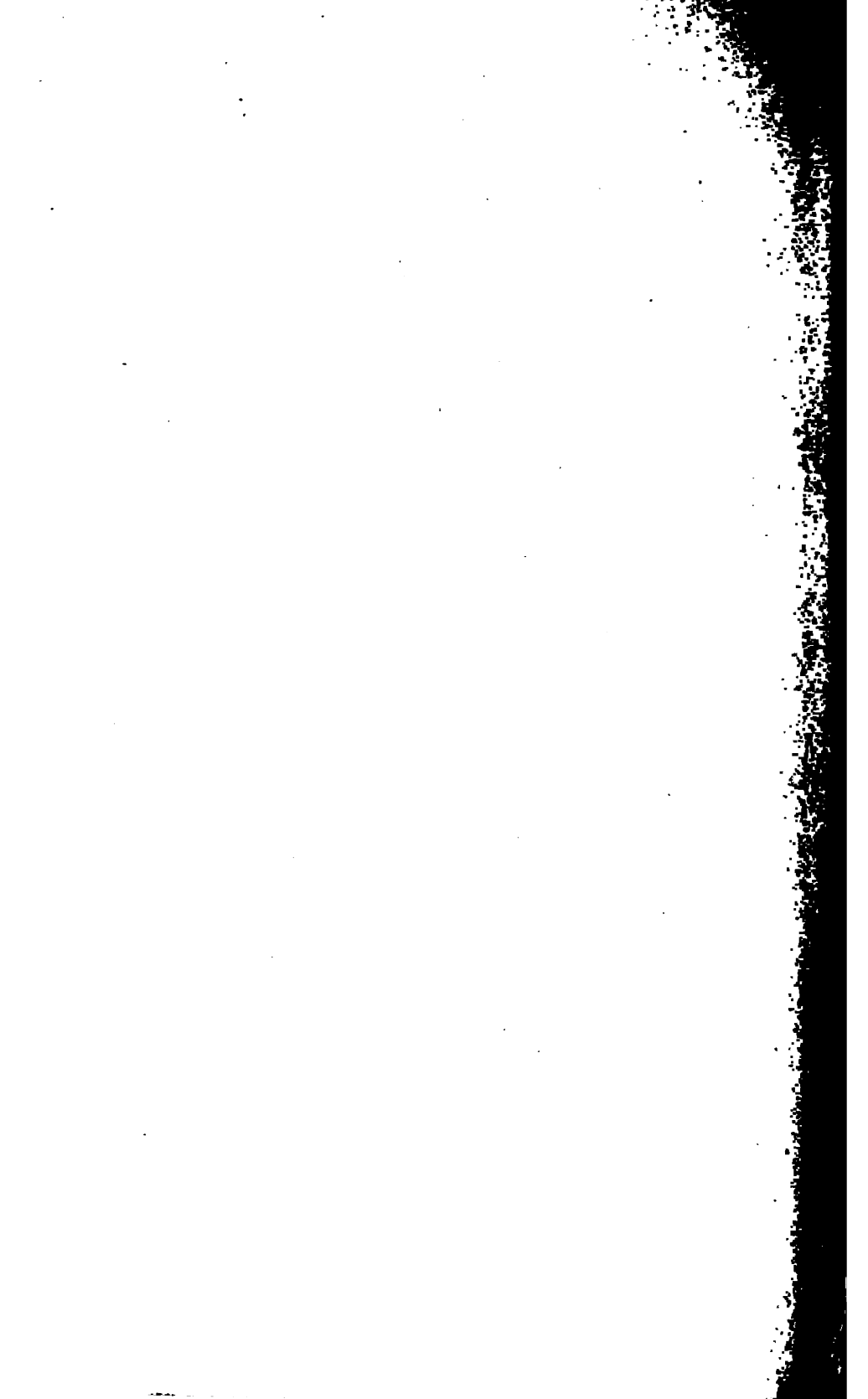
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·JOURNAL

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CONTENTS.

AN EXPERIMENTAL STUDY OF VISIONS.   (ABSTRACT.)

MORTON PRINCE, M.D.

If it had been understood that many historical visions were
only the pictorial representation in consciousness, accòrding
to natural psychical laws, of the thoughts, prayers, or beliefs
with which the religious enthusiast had occupied his mind at
some time perhaps long forgotten, history would doubtless
read differently.   It is well known that certain persons have
the faculty of creating visions at will, usually by the process
called " crystal gazing," but it is not so commonly understood
that " spiritualistic mediums " artificially cultivate the seeing
of visions by practically the same method.

Visions thus created probably.do not differ in genesis from
those occurring spontaneously in normal persons, and may be
the product of the same psychical laws as arę some of the
hallucinations of the insane.   In most all observations hitherto
reported it has been impossible to thoroughly investigate
the relation of the visions to antecedent events in the subject's
life, beyond the waking memory of that person, but with the
reader's subject it was possible to hypnotize and obtain two
additional and distinct personalities, and thus revive facts
long forgotten by the normal personality.

The visions could be divided into three groups:

A — Including revivals of past *visual* experiences, either conscious or sub-conscious.

B — Others, not revivals, but largely newly-created visual repetitions of past experiences *other than* visual.

C — Neither revivals nor representations of past experience (visual or other) so far as known.

The mode of producing the hallucinations was to have the subject gaze into a glass bulb, when, after a few seconds, she saw various scenes acted before her.

The visions were not seen like small objects reflected in or on the glass bulb, but the bulb disappeared and the scene described appeared before her, the characters being life-size and like living persons. The visions were like ordinary hallucinations or vivid dreams, the scenes real, of life size, but dissociated from the subject's surroundings. In two experiments of the first class the vision was a representation of past experiences of the subject, but which had been forgotten. In Experiment III. certain things were portrayed which the waking consciousness apparently never perceived, but which were seen by the so-called unconscious part of the mind. In Experiment IV. an absent-minded and a somnambulistic act were seen in the glass. In Experiment V. a complicated series of acts done in the delirium of pneumonia reappeared as a vision. Experiment VI. shows how a vision may be constructed out of certain past familiar and certain other experiences of which no optical images could have been had — a new synthesis of images being created by the force of imagination and known facts. Experiment VII. probably represented something she had read, etc.

Visions may partake of the characteristics of the three classes above, being partly revivals, partly representations of actual non-visual experiences, and also of the subject's knowledge, inferences, and thoughts. Generalizing, it is possible that hallucinations of the other senses, especially of hearing and as exhibited by trance mediums, may have a similar origin and composition. It is probable that thoughts which have strongly absorbed the mind and expressed the longed-

for ambition of the subject may appear as visions. The subjects are then apt to look upon them as inspirations. In this way have arisen the visions of political personages like Joan of Arc, Mohammed, and religious enthusiasts like Luther, Savonarola, Catherine of Sienna, and others.

Visions, artificially created, may be representations and revivals of the experience of the hypnotic personality, of which experience the waking consciousness never has had knowledge. Impressions on the sense organ which never entered consciousness (and therefore never known or remembered) may afterwards appear as visions.

CONCLUSIONS. — *First.* Visions in sane persons may be revivals of past visual experiences which originally may have been conscious or sub-conscious. The original subconscious experience may have occurred in a moment of absent-mindedness, or may not have been sufficiently intense to have entered consciousness, or (rarely) may have occurred in somnambulism.

Second. The vision, instead of being a revival, may be a newly created pictorial representation of a past experience other than visual. That is to say, past impressions of one or more senses (touch, hearing) and actions may translate themselves into representation by another sense as a vision.

Third. It is probable, though not proved, that a vision may not reproduce or represent any past experience, visual or other, but may be newly created out of something the subject has read, heard, or thought. The inference from, and passing thoughts about, known facts may weave themselves into visions. This was probably the origin of the visions of Joan of Arc and religious enthusiasts.

Fourth. Visions may partake more or less of the characteristics of these classes, being partly revivals, partly representations of actual non-visual experiences, and also of the subject's knowledge, inferences, and thoughts.

Fifth. Generalizing, it is possible that hallucinations of the other senses, especially of hearing, and as exhibited by trance mediums, may have a similar origin and composition.

Sixth. Analogous phenomena may be observed in the

attacks of hysterics where the passing thoughts in the nor-
mal state may appear as insistent ideas in the attack.

Seventh.   It is probable that thoughts which have strongly
absorbed the mind and expressed the longed-for ambition or
ideas and beliefs of the subject may appear as visions.   The
subjects are then apt to look upon them as inspirations.   In
this way may have arisen the visions of political personages
like Joan of Arc, Bismarck, and religious enthusiasts like
Luther, Peter the Hermit, Catherine of Sienna, and others.

Eighth.   Visions, artificially created, may be representa-
tions and revivals of the experiences of the hypnotic person-
ality, of which experience the waking consciousness never
has had knowledge.

Ninth.   Impressions on the sense organ which never
entered consciousness (and therefore never known or remem-
bered) may afterwards appear as visions.

A SIMPLE COLLECTOR AND SEPARATOR FOR SEDIMENTS.

W. F. WHITNEY, M.D.

The apparatus consists of a glass funnel, to the stem of which a short piece of glass tubing, drawn to a fine point, is closely attached by a tight collar of rubber tubing.   The small opening in the end should be closed, first by placing it against the centre of a narrow strip of sheet rubber (1 cm. wide by 9 cms. long) which is drawn tightly up and secured, thus stretched over it, by a few turns of string around the ends, while they are held firmly against the tube.   (See figure.)

The fluid is poured into the funnel and the sediment can all be collected in the stem and drawn off drop by drop, if desired, on relaxing the rubber closing the opening, by gently pressing the strip down with the fingers.   In this way different layers of the sediment can be quickly examined without danger of mixing them, or particles, which can be easily seen through the glass, can be obtained.   Or one drop can be drawn from the bottom and another taken from the top, with an ordinary pipette, for comparison.   Its value is evident, where only a very small amount of sediment is present in a fluid ; and as a substitute for the centrifugal machine it recommends itself by its cheapness, simplicity of construction, and ease of manipulation.

The adaptation of the rubber strip for the purpose of closing the end of the pipette, upon which the efficacy of the apparatus depends, is the idea of Dr. S. J. Mixter.

Dr. Whitney also showed :

A ready means for tracing outlines of sections of tumors, or fresh organs.   It consists simply of placing a piece of ground glass over the surface, the outline of which can be sketched on the glass, and can then be readily traced on ordinary paper by holding it up to the light.

EXPERIMENTS UPON THE GERMICIDAL PROPERTIES OF BLOOD SERUM.

FRANKLIN W. WHITE, M.D.

(From the Pathological Laboratory of the Massachusetts General Hospital.)

It is only about twelve years since Nuttal first demonstrated the fact that the blood serum of animals is germicidal for certain bacteria. The importance of this discovery was at once recognized, and this property of the blood has been regarded as one of the chief defences of the human body against the invasion of pathogenic bacteria. Much inaccuracy has arisen, however, in the general conception of this property of the serum, from a failure to recognize that the action of human and of animal serum may be very different upon the same bacterium, and furthermore that all kinds of bacteria are by no means equally affected by human serum, some being promptly destroyed by it, while others are hardly affected.

In testing the germicidal properties of blood it seems desirable to submit the bacteria to the action of the blood in the living body if possible, but injection of bacteria into the blood of animals with subsequent examinations of this blood has proved to be an unsuitable method, for Wyssokowitch and others have shown that bacteria which are injected into the blood vessels of animals are rapidly filtered out by such organs as the liver and kidneys, and may disappear promptly from the blood stream without reference to any germicidal action of the serum. The usual method, therefore, has been to obtain the blood by cupping, aspiration of a vein, or other means, and after separation of the serum by simple clotting or by defibrination of the blood, to inoculate it with the bacteria to be tested, and determine their fate by making cultures of a small portion of the serum at intervals after inoculation.

Nissen, Buchner, and others have shown that the germicidal substance in blood serum is not a product of chemical changes at the time of clotting, but is present in uncoagulated

blood and body fluids coming from blood plasma, so the
method seems a fair one.

We began our experiments with the object of finding out:

First. What action normal human serum has upon the
pus organisms.

Second. Whether the blood serum in cases of chronic
wasting disease is less germicidal than normal.

Third. What changes occur in the germicidal properties
of the serum near the time of death.

I. *Action of Normal Human Serum on the Pus Organisms.*

Previous writers have not wholly agreed as to the effect of
human serum on the pus cocci, the majority stating that it is
quite without effect, while one or two men (Flexner, Rovighi)
claim to have demonstrated a germicidal action upon the
Staphylococcus Aureus and Pneumococcus which is dimin-
ished or lost in cases of chronic disease.

We chose the Staphylococcus Pyog. Aureus and Strepto-
coccus Pyog. for our experiments because they are the bacteria
most commonly concerned in the production of general sep-
ticemia, and of secondary and terminal infections in chronic
disease, and because the disagreement of previous results
seemed to make further experiments desirable. Incidentally
in a few instances the serum was tried upon typhoid bacilli
for control.

The normal blood was obtained from healthy surgical cases
at the Massachusetts General Hospital and convalescent
medical cases just before discharge from the hospital, also
from healthy young women in the Boston Lying-In Hospital.
In the obstetrical cases the blood flowing from the uterus
after delivery was used ; in the other cases blood was obtained
by aspiration of a superficial arm vein.   The serum was
obtained by natural clotting of the blood, was inoculated with
the bacteria to be tested, and duplicate portions of the serum
plated on agar at intervals of two, six, and twenty-four hours
after the inoculation.   In several experiments serum warmed
to 55° C., and thus deprived of its germicide powers, was used
for control.

In the seventeen serums which were inoculated with the Staphylococcus Aureus (with the exception of one case) there was no evidence of any germicidal action, but on the contrary there was a progressive growth of the cocci, varying in rapidity in different cases, and the blood serum caused at most only a temporary delay in their growth. The prompt destruction of typhoid bacilli by several of these specimens of serum is in sharp contrast to the lack of influence upon the pus cocci.

In the six cases where serum was inoculated with the Streptococcus Pyog. there was no evidence of any germicidal action, but likewise a progressive growth of cocci in the serum.

Previous experiments " in vitro " have shown conclusively that human blood serum is germicidal for various bacteria such as anthrax, typhoid, colon, and cholera bacilli, and it has been concluded that one of the chief defences of the body against the invasion of pathogenic bacteria lay in the germicidal properties of the blood and body fluids. Our similar experiments " in vitro " have shown that normal human serum possesses little or no germicidal power over pus organisms. One thing is certain, namely, that we can make no sweeping statements about the action of human serum upon bacteria in general, but must remember that it possesses a definite specific action upon certain bacteria, and not upon others.

II.   Blood Serum in Chronic Disease.

We know that chronic disease plays an important part in determining susceptibility to bacterial infection, and it seems possible that in individuals with chronic disease a modification in the quality of the blood and tissue fluids, a lessening of their germicidal power, may be one of the important factors in producing this increased susceptibility. We could hardly expect to show a contrast between health and disease by using pus cocci for these experiments, for we have just seen how little they were affected even by normal serum ; therefore some common bacteria which are promptly destroyed by normal blood were chosen, namely, colon and typhoid bacilli.

The patients furnishing the serum were ten in number, and comprise cases of severe cachexia, such as pernicious anemia, chronic heart and kidney disease, abdominal cancer, sarcoma, etc.   The results show that in each case of chronic disease the blood serum was still actively germicidal to the typhoid and colon bacilli, and about equally so in the different cases. Two samples of serum which were heated before inoculation (to destroy the germicidal substance) form a sharp contrast to the other serums.

We have no desire to make too wide an application of the results of experiments " in vitro," but it seems to us that the fact which is so clearly shown, namely, that human serum is very destructive to colon and typhoid bacilli, and has very little effect upon pus cocci, may afford an explanation of the relatively frequent finding of pus organisms in the blood during life in cases of septicemia, pyemia, endocarditis, tuberculosis, etc., and the comparative rarity of finding either colon or typhoid bacilli in living blood in intestinal or other disease.   In short, of the bacteria which we have tested, the ones commonly found in the blood in disease are just the ones we should expect to find there, considering the properties of the blood serum.

III.   Changes in Human Blood Serum occurring near the Time of Death.

It is a well-known fact that normal human blood serum destroys the colon bacillus, and it has been sufficiently proved that this germicidal property of the serum is retained in severe cases of chronic disease.   We also know that the colon bacillus is frequently found in living active condition in the blood and organs at autopsies in all kinds of acute and chronic diseases.   From these facts it is evident that at some period in the course of fatal disease, either at the latter end of life, during the death agony, or after death, the germicide power of the blood serum for the colon bacillus must be lost. An attempt was made to find out the exact time when this change in the properties of the serum occurs, by testing

samples of blood taken shortly before and after death in a mixed class of cases.

The cases, nineteen in number and all fatal, comprise anemia, nephritis, cancer, myocarditis, sepsis, cerebro-spinal meningitis, acute pancreatitis, skull and rib fractures, etc. The blood was obtained before death by aspiration of a vein, and after death by aspiration of the heart. Blood cultures were made in all the cases; an autopsy was performed in one-half of them.

The twenty-six specimens of serum inoculated with colon bacilli differ greatly in their germicidal power for these bacilli. All the serums obtained before death showed germicidal power for the colon bacillus, but in two cases it was very much weakened. In about one-third of the cases the serums obtained shortly after death were found to have lost their germicidal power. In about one-half of the cases post-mortem serum was more or less germicidal, up to three and four hours after death in several cases.

In seven cases the blood of the same patient was tested both before and after death. In three of these the blood was markedly germicidal ante mortem, and not germicidal post mortem. In one case the blood was slightly germicidal before death, and not germicidal after death. In three cases the blood was germicidal both before and after death.

We should expect the presence or absence of germicidal power in the blood serum to strongly influence the invasion of the body by colon bacilli during the death agony or after death. The reports of the autopsies which were performed in seven of our cases bear out this theory. In four cases in which the blood serum was germicidal, no colon bacilli were found in the organs at autopsy. In two cases whose blood examined shortly after death was not germicidal, colon bacilli were found in some of the organs at autopsy.

We have seen that in two of our cases weakening of the germicidal properties of the serum occurred shortly before death, and in others the blood showed an absolute loss of germicidal power promptly after death (which probably means that in these cases also there was some weakening shortly

before death occurred), and in other cases the germicidal powers of the blood were retained for several hours post mortem. We cannot connect these facts with the course of disease in the individual, but they undoubtedly have an important bearing on agonal and post-mortem invasion of the body. For example, in some cases the germicidal properties of the blood are weakened or lost in the last hours of life, general bacterial invasion of the body is undoubtedly favored, bacteria enter the blood stream, are scattered about to the organs, and are found at autopsy, even when the latter is performed within a few hours after death. In many other cases, however, the blood retains its germicidal properties till after death, general invasion of the body is prevented or hindered, and colon bacilli only reach the organs by post-mortem outgrowth from the bowel.

I believe that agonal invasion of the body by colon bacilli is not a general or very common occurrence, from a consideration of the animal experiments of Austerlitz and Landsteiner, from the small number of our cases in which bacteria were found in the blood post mortem, and from the fact that the blood serum retained its germicidal powers for the colon bacillus till hours after death in one-half our cases.

We will summarize our conclusions as follows:

1. Human blood serum differs greatly in its germicidal action upon various kinds of bacteria.

2. Our experiments indicate that normal human blood serum is not actively germicidal for the Staphylococcus Pyog. Aureus or the Streptococcus Pyog.

3. Human blood serum does not lose its germicidal power for typhoid and colon bacilli even in the late stages of chronic wasting disease.

4. Human blood serum in fatal disease occasionally loses part of its germicidal power for the colon bacillus shortly before death, but more frequently retains its germicidal power for this bacillus for several hours after death.

5. A weakening of germicidal power of the blood serum shortly before death undoubtedly favors an agonal invasion of the body by the colon bacillus.

THE ACTION OF THYROID EXTRACTS ON THE ISOLATED MAMMALIAN HEART APEX.[1]

ALLEN CLEGHORN.

(*From the Laboratory of Physiology in the Harvard Medical School.*)

These experiments were done on the dog's ganglion-free apex, according to Porter's method, to determine the action exerted by iodothyrine and thyroid extracts on contracting cardiac muscle.

Experiments were made with glycerine and saline extracts of the gland, iodothyrine (prepared according to Baumann's method), and iodine (.05 per cent.) dissolved in a normal saline solution (0.8). The results obtained from iodothyrine, glycerine, and saline extracts were similar in every respect.

Perfusion of a fluid containing 3 per cent. of the extracts augmented the contractions and slightly quickened the rhythm of the apex, but the effect gradually wore off. Large doses — 10–15 per cent. — exerted a contrary effect, a marked fall in the tonus of the heart taking place, and the contractions becoming considerably smaller and slightly slower. Perfusion of these large doses continued for some time eventually paralyzed the apex.

In all cases the thyroid extract or iodothyrine appeared to exert a regulating influence on the rhythm of the contractions. When the apex was contracting in a slow and irregular manner during normal perfusion, regular and rhythmic contractions were invariably produced when the thyroid extract was turned on, and at the same time the contractions were slightly quickened and augmented. On resuming normal perfusion again the apex remained contracting in a regular manner, but as a rule with an accelerated rhythm.

Perfusion of the iodine solution had an entirely different effect. At first the contractions were increased in size, they gradually fell to their normal before the end of the perfusion, a slight rise in the tonus of the apex gradually took

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[1] Reported in full in the "American Journal of Physiology," No. 3, Vol. II., 1899.

place, and the apex became very irregular in its contractions. This irregularity of the contractions lasted for a considerable time after resuming the normal perfusion, but the rising tonus returned at once to its normal level.   It appears from these experiments, therefore, that iodothyrine and iodine exercise an antagonistic action on contracting cardiac muscle.

IMMEDIATE EFFECTS UPON THE SPINAL CORD OF FRACT-
URES OR DISLOCATIONS OF THE VERTEBRÆ.

E. W. TAYLOR.

(*From the Sears Pathological Laboratory, Harvard Medical School.*)

(*Preliminary Report.*)

The following two cases are reported in abstract prelimin-
ary to a more complete piece of work by Drs. S. A. Lord and
E. W. Taylor on the effects upon the central nervous system
of violent injuries to the vertebræ.

CASE I.   Woman; fall of thirty feet·from a trapeze into a
net; fracture of spine in region of sixth cervical segment.
Paralysis, laminectomy; death on the third day.

Cord — macroscopic appearances. — Dorsal aspect shows a
slight blue discoloration one cm. in length between the sixth
and seventh cervical segments; this discoloration is more
marked on the ventral side.   Absolutely no extra- or intra-
dural hemorrhage.   A transverse section at the point of
greatest injury shows hemorrhagic softening, involving the
whole transverse area, excepting a small portion of the dorsal
white tracts.   Above this point, extending through four seg-
ments, is a tubular hemorrhage in the dorsal white matter,
most marked in the third segment.   Below the area of soften-
ing there is considerable hemorrhage within the substance of
the cord for a distance of several cms.   Another tubular
hemorrhage, similar in position and extent to the one in the
upper cervical region, may be traced through the second,
third, and fourth thoracic segments.

Microscopic examination in general verifies the appearances
as seen in gross.   At the point of greatest injury the gray
and white matter are not to be distinguished from each other.
The myeline shows evidences of disintegration, but is still
stainable in part by the Weigert method.   There is much fresh
hemorrhage throughout the cord, but none external to it.
The tubular hemorrhage in the upper cervical region is
limited to the white matter, a more unusual situation than in
the gray horns.   The eighth cervical segment below the

chief lesion shows considerable heterotopia of both gray and white matter, due to mechanical causes. In general the injured cord shows but slight distortion of shape.

The case is of interest on account of the fact that the blow, although chiefly exerted at one small point, was sufficient to cause hemorrhages in the white matter at considerable distances above and below that point. Bailey[1] has recently called attention again to the importance of recognizing hemorrhage of this character, even when unassociated with a transverse lesion of the cord. The absence of external hemorrhage is noteworthy, but in our experience the usual condition.

CASE II.   Man; said to have fallen and struck head. Paralysis; absence of deep and superficial reflexes below point of injury. Depression of spine over sixth cervical vertebra. Laminectomy; death seventeen days after receipt of injury. Autopsy showed the fifth vertebra dislocated forward on the sixth, with rupture of the intervertebral ligament.

Cord — macroscopic appearances. — Exceptionally large cord. Before opening the dura appearances normal, with no extradural hemorrhage. On opening dura dorsally no hemorrhage, nor sign of other pathological condition. By palpation an area of softening with a longitudinal extent of about one cm. may be made out. The cord is not completely destroyed at this level. Pia intact. The dura, opened on ventral aspect of cord, shows likewise no hemorrhage beneath it. At an area corresponding to the upper edge of the softened portion, and extending a distance of about four cms. down the cord, there is a rupture in the line of the ventral fissure which involves the pia, but not the dura.

On section it appears that the softening has involved primarily the gray matter. At the level of greatest destruction the horns are almost completely disintegrated, though surrounded in great part by undisturbed white matter, through which, undoubtedly, conduction could take place. Below the point of softening there is destruction of the ventral horns, with hemorrhage into them. Above the point of injury as far as the upper cervical region there is hemorrhage sharply

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[1] " Med. Record," Nov. 19, 1898, p. 731.

limited to the dorsal and ventral horns, decreasing in amount from below upward. The white matter appears normal. The oblongata is not involved. The lower portions of the cord were not obtainable for study.

Microscopic appearances. — On cutting and staining, the complete central destruction of the cord is of interest at the point of chief violence. Surrounding the destroyed gray matter is a layer of normally staining myeline fibres, giving to the cross section somewhat the appearance of a syringomyelia. Just below this level the ventral white matter as well as gray has suffered, and still further down the only marked appearance of injury is a fracture which extends in through the ventral fissure, enters the ventral horn, and extends through the dorsal horn of the same side at one point almost to the dorsal periphery. In the upper cervical segments the lesion confines itself to the horns, which show hemorrhage, and also on one side a split, which probably was due to the original violence and not to later manipulation. Secondary degenerations are insignificant, both because of the short time between the injury and death and also because the white tracts are nowhere completely interrupted.

Of interest in this case is the character of the chief lesion, and its tendency to confine itself almost wholly to the gray matter, with distant hemorrhages in the gray rather than in the white matter, unlike the first case. The absence of deep reflexes in a lesion of the cord not completely transverse is an observation of importance.

The two cases tend to show that in spite of violent injury to the cord there may be no extra- or sub-dural hemorrhage; that the lesion of the cord once made is irreparable; and that operation in cases in which there are symptoms of transverse lesion is unavailing and illogical.

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on January 17, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

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JOURNAL

OF THE

Boston Society of Medical Sciences

CONTENTS.

A CONTRIBUTION TO THE PATHOLOGICAL HISTOLOGY
OF ACUTE TONSILLITIS.

J. L. GOODALE.

(*From the Laboratory of the Massachusetts General Hospital.*)

The fullest account of the pathological histology of acute tonsillitis, since its bacteriological separation from diphtheria, was given by B. Fraenkel in 1895. He found the changes to consist essentially in a greatly increased emigration of leucocytes from the follicles into the crypts, a condition which he attributes to an actual inflammation of the parenchyma of the tonsil. Cocci were found in the tonsillar tissue, at times in the interior of the follicles. No details were given in his paper either in regard to the cells of the organ or to the special localization of microörganisms in the tissues.

The following paper embodies the results of a histological examination of sixteen cases of acute tonsillitis.   In all the bacillus of diphtheria was shown to be absent.   No attempt was made to classify the cases according to the forms of cocci present, as mixed cultures were generally obtained of streptococcus pyogenes, staphylococcus pyogenes aureus and albus.

The specimens were excised during life and immediately placed in the fixing fluids, alcohol and Zenker's fluid being chiefly used. Healing was in all cases rapid and without complications.

The duration of the affection at the time of excision of the specimen ranged from one day to two weeks, in the majority of cases being from three to four days.

Two distinct types of histological lesions were encountered. In all cases a diffuse proliferation of the lymphoid and tissue cells was present. Four cases showed also local foci of suppuration in the follicles.

Diffuse Proliferative Changes.

The follicles exhibit an enlargement, due to an increased number of their lymphoid cells and of the endothelioid cells of the reticulum. In cross-section the central reticulum preserves its ordinary circular or oval outline, while the encircling ring of lymphoid cells is most markedly widened on the side adjacent to the nearest crypt. The endothelioid cells of the reticulum show an increased number of mitoses. Scattered among these endothelioid cells are a varying number of large phagocytic cells, characterized by a relatively large amount of markedly acidophilic cytoplasm and an irregular, lightly staining, eccentrically situated nucleus. They contain in their interior from one to ten or fifteen cells or cell fragments, which are generally lymphoid cells, less frequently red blood corpuscles. The incorporated cells and fragments do not appear to lie directly in contact with the cytoplasm of the phagocytic cell, but are generally situated in clear spaces or vacuoles. Occasionally these phagocytes are found fixed in irregular shapes suggestive of amoeboid movement.[1]

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[1] These phagocytic cells cannot be considered as characteristic of tonsillitis, as I have frequently seen them in tonsils in which there was no evidence of inflammation. In normal tonsils their number is relatively small and is in general proportionate to the number of mitoses present in the endothelioid cells, from which they are supposed to be derived. They are undoubtedly identical with the cells described by Mallory under the name of epithelioid cells with phagocytic properties occurring in the intestinal follicles in typhoid fever.

The lymphoid cells occupying the periphery of the follicle are increased in number in all cases, and are often so closely packed together that the reticulum can be distinguished only with difficulty.

The interfollicular regions show an increased proliferation of the endothelioid cells of the reticulum, together with an increase in the numbers of lymphoid cells. Occasionally large phagocytic cells are found here similar to those in the interior of the follicles. In the immediate neighborhood of the follicles the lymphoid cells are all of typical appearance, but as the mucous membrane is approached many begin to exhibit changes. Their cytoplasm becomes more abundant and shows a greater affinity for alkaline methylene blue, while the nucleus becomes more coarsely granular and lies eccentrically. In the loose mucous membrane of the crypts cells are found with the preceding characters more pronounced, appearing here as cells from two to four times the diameter of a red blood corpuscle, with a cytoplasm which is denser at the periphery than in the centre, and stains deeply with alkaline methylene blue, possessing an eccentric nucleus with coarse, deeply-staining, chromatin masses regularly · arranged at its periphery, from which a characteristic chromatin network extends into the interior. From the preceding characters, these cells are to be considered as identical with the plasma cells of Unna.[1] Polynuclear neutrophiles occur in small numbers scattered through the interfollicular region, and may occasionally be seen escaping through the walls of the blood-vessels. They are in no place collected together into groups.

The blood-vessels are filled with red and white blood corpuscles, the latter consisting of small mononuclear lymphocytes and polynuclear neutrophiles in about equal proportion. The endothelioid cells of the blood-vessels are more or less swollen, occasionally show mitoses, and in places are seen to be detached from the vessel wall, and to be lying free within the lumen.

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[1] These plasma cells also occur in the same situations in tonsils which are not inflamed, although here they are less numerous.

In the fibrous trabeculæ near the base of the tonsil poly-nuclear eosinophiles are found in larger numbers than ordinarily.

The cells of the mucous membrane show an active pro-liferation and exfoliation. In the compact epithelium cover-ing the free exposed surface of the tonsil polynuclear neutrophiles were found more abundantly than usual, but lymphoid cells and plasma cells were not here found. In the loose thin epithelium of the crypts, however, lymphoid and plasma cells occurred in abundance, together with a relatively small number of polynuclear neutrophiles. Many are seen on the point of escaping from the intercellular channels of the epithelium into the crypts.

Bacteria, chiefly cocci, were found in a few places super-ficially in the epithelium lining the crypts. In a few cases a single coccus was found here and there in the submucous tissue. None were, however, found at a greater distance from the crypts in the cases under description.

The crypts are filled with exfoliated epithelial cells, leu-cocytes, bacteria, amorphous *débris*, and in some cases fibrin. The leucocytes are chiefly polynuclear neutrophiles, many of which contain bacteria in their interior. Some show nuclear fragmentation with dispersion of their chroma-tin. There are also seen smaller numbers of lymphoid cells, plasma cells, and cells intermediate in character between those two. Bacteria are most abundant near the orifice of the crypt, gradually diminishing in numbers towards the base, which at times seems nearly free from them. Fibrin is seen in the cases of greater clinical severity, occurring as a delicate network enclosing cells and bacteria. At times the fibrin may be seen extending from the crypt into, and even beyond, the epithelium. It penetrates most deeply in the interfollicular regions, and is not found in the centre of the follicles. In connection with this fact the experiments on tonsillar absorption may be recalled which I reported before this Society in 1897. In these it was demonstrated that foreign substances introduced into the crypts of the tonsil made their way into tonsillar tissue in the interfollicular

regions, a result which was subsequently confirmed by Kay-
ser and Hendelsohn.

Focal and Suppurative Lesions.

These occurred in four cases under the form of abscesses,
situated at the beginning in the interior of the follicles, later
enlarging and eventually discharging into the crypts. The
relative frequency of these abscesses varied in the different
cases. Thus in one case a single small abscess was found in
an examination of many serial sections. In two cases about
one follicle in ten was the seat of abscess formation, while in
a fourth instance nearly every other follicle was thus affected.
The follicles without abscess formation and the interfollicular
regions showed general proliferative changes similar to those
already described in the preceding twelve cases.

The presence of an abscess in its early stage is indicated
by a circumscribed infiltration of polynuclear neutrophiles
among the endothelioid cells of the reticulum occupying the
centre of the follicle. The blood-vessels in the immediate
neighborhood contain large numbers of polynuclear neutro-
philes, of which many are seen in the act of passing through
the vessel wall. The endothelioid cells of the vessels show a
varying amount of swelling. Micrococci are found in varying
numbers in the region occupied by the polynuclear neutro-
philes, lying for the most part free in the intercellular spaces,
although they not infrequently may be seen in the interior
both of the polynuclear neutrophiles and of the large endo-
thelial phagocytes previously described. With the growth of
the abscess the follicle increases very considerably in size,
as the result largely of a heightened proliferation of the endo-
thelioid cells of the reticulum. These in the immediate
neighborhood of the abscess show a swelling of their cyto-
plasm and an irregularity in outline of their nucleus, which
appears elongated, indented, or twisted. A marked increase
is simultaneously observed in the number of large phagocytes
in the vicinity, which contain also a greater number of incor-
porated cells and fragments. The growth of the abscess is
always in the direction of the nearest crypt. The poly-

nuclear neutrophiles of the abscess first penetrate in a more or less compact wedge the dense collection of lymphoid cells which encircles the central reticulum, and advancing towards the mucous membrane of the crypt, infiltrate this and cause it to become exfoliated over a definite area. The abscess now discharges freely into the crypt, which becomes filled with polynuclear neutrophiles, cellular detritus, and bacteria. Lymphoid and plasma cells are relatively less abundant than in cases without abscess formation. Fibrin in the crypts appears, on the other hand, more abundant. The relative size of the abscesses varies greatly in the different follicles in the same tonsil, some being barely recognizable, while others are already discharging into the crypts. Occasionally two or even three abscesses are found in a single follicle, and these are generally of different sizes.

The four cases showing these foci of suppuration gave a history of acute inflammatory symptoms ranging from four to six days at the time of excision of the specimen. In none of them was there evidence of a beginning reparative process, so that material illustrating this is still to be desired.

Conclusions. — Acute tonsillitis due to infection by the streptococcus pyogenes and the staphylococcus pyogenes albus and aureus is characterized histologically by a diffuse inflammation of the parenchyma of the organ, appearing in the form of an increased proliferation of lymphoid cells and of the endothelioid cells of the reticulum, due probably to the absorption of a toxine formed in the crypts. While bacteria are rarely demonstrable in the tonsillar tissue in cases characterized by purely proliferative lesions, yet at times infection of the interior of the follicle occurs, giving rise to circumscribed suppuration and the formation of abscesses which eventually discharge into the crypts.

(My thanks are due to Dr. J. H. Wright, Director of the Laboratory of the Massachusetts General Hospital, and to Mr. Brown of the Laboratory, for the preparation of the micro-photographs.)

B. Fraenkel : Die infectiöse Natur der Tonsillitis Lacunaris. Archiv für Laryngologie, etc., IV. Band, 1 Hft.

Mallory : Journal of Experimental Medicine, Vol. III., No. 6.   Also Journal of The Boston Society of Medical Sciences, Vol. II., No. 1.

Goodale : The Absorption of Foreign Substances by the Faucial Tonsils, etc. Journal of The Boston Society of Medical Sciences, Vol. I., No. 14, May, 1897. Also in the Proceedings of XII. International Congress, Moscow.

Goodale : Ueber die Absorption von Fremdkörpern durch die Gaumentonsillen, etc. Archiv für Laryngologie, etc., VII. Band, 1 Hft.

Kayser : Ueber das Verhalten der Tonsillen gegen Fremdkörper. XII. International Medical Congress, Moscow, 1897.

Hendelsohn : Ueber das Verhalten des Mandelgewebes gegen aufgeblasene pulverförmige Substanzen. Archiv für Laryngologie, etc., VIII. Band, 3 Hft.

DESCRIPTION OF PLATES.

PLATE I.

FIG. 1. — Three follicles are seen adjacent to a crypt, showing a diffuse proliferation of moderate intensity. In each follicle a dark ring of lymphoid cells surrounds the lightly staining centre of endothelioid cells. The small irregular deficiencies in the centre of the follicles and in the adjacent tissue represent the vacuoles of the large phagocytic cells.

FIG. 2. — Section through a follicle adjoining a crypt, showing a small abscess in the centre.

Both sections are stained with alkaline methylene blue and eosin.

PLATE II.

FIG. 1. — Section through an abscess in the centre of a follicle, showing the sharply circumscribed collection of polynuclear neutro-philes, surrounded by endothelioid cells, many of which exhibit distortion of their nuclei.

Alkaline methylene blue and eosin staining.

FIG. 2. — Section, stained by Weigert's method, showing fibrin in mucous membrane of crypt and extending in places to submucous tissue. The crypt occupies the lower right-hand corner of the field; the mucous membrane runs obliquely from above downward and to the left.

PLATE III.

FIG. 1. — Section through mucous membrane and adjoining portion of crypt, stained for bacteria by Gram's method. Cocci are seen in great numbers in the crypt lying both free and in the interior of polynuclear neutrophiles. None are seen in the mucous membrane.

FIG. 2. — Section through a beginning abscess in a follicle, stained by Gram for bacteria and counterstained with saffranin. Immediately above the deficiency near the centre of the field is a large epithelioid phagocyte containing in its interior a lymphoid cell and a coccus, the latter lying immediately below the nucleus of the phagocyte. To the left of the centre is a polynuclear neutrophile containing three cocci. Other cocci are seen lying free in the vicinity.

Fig. 1.

Fig. 2.

GOODALE.
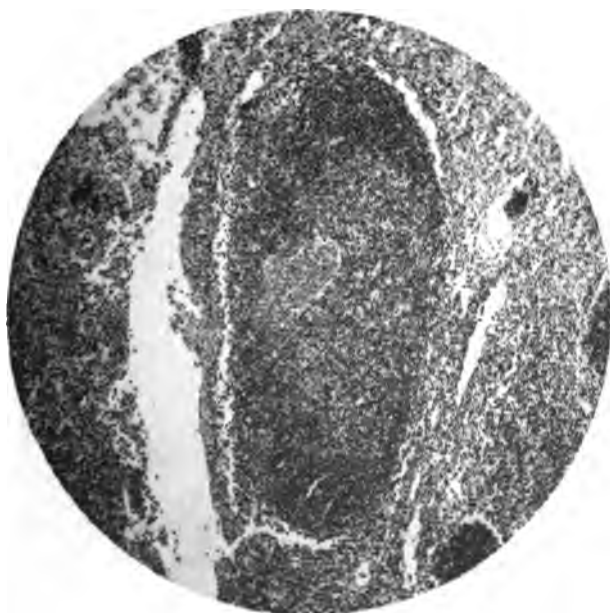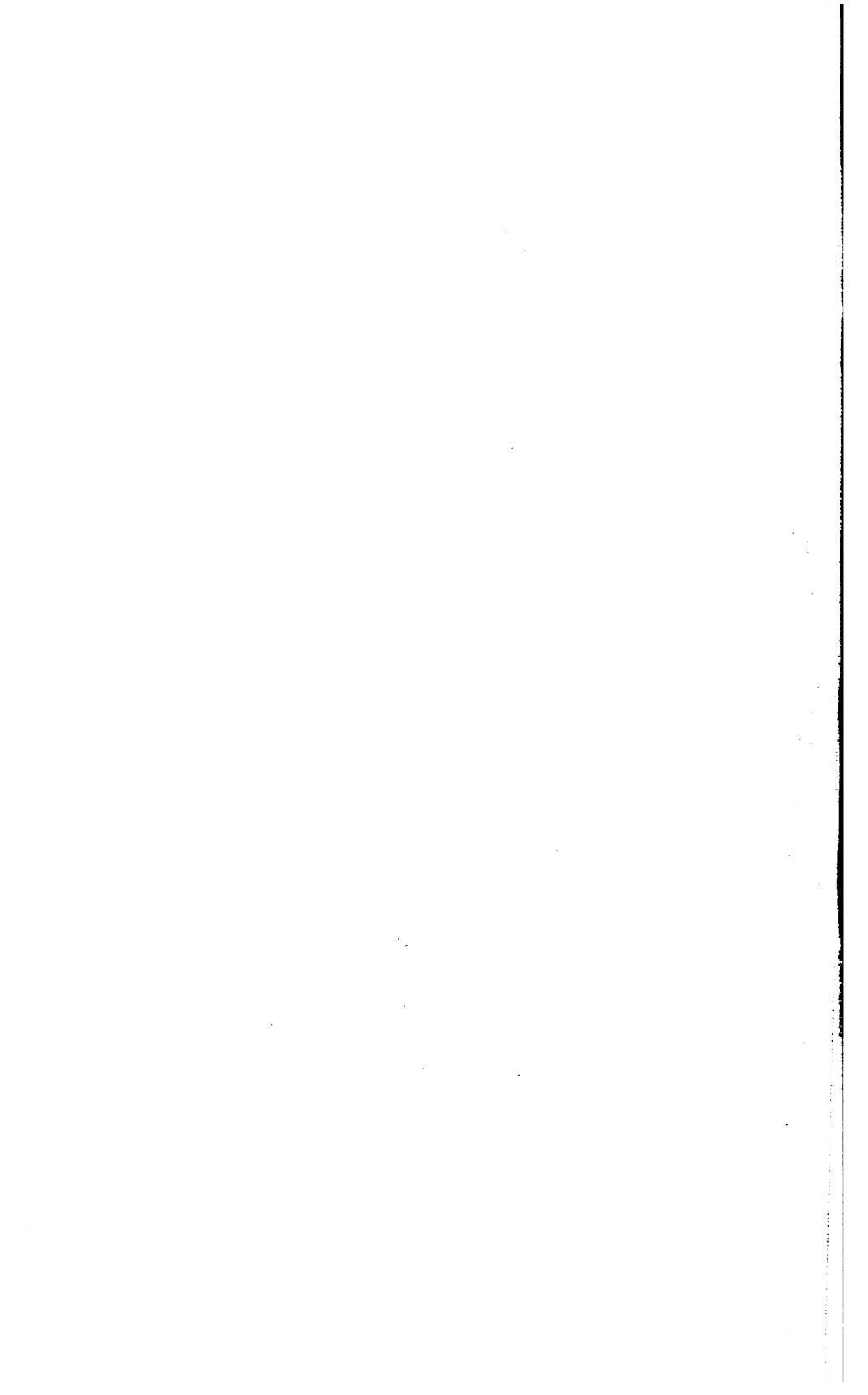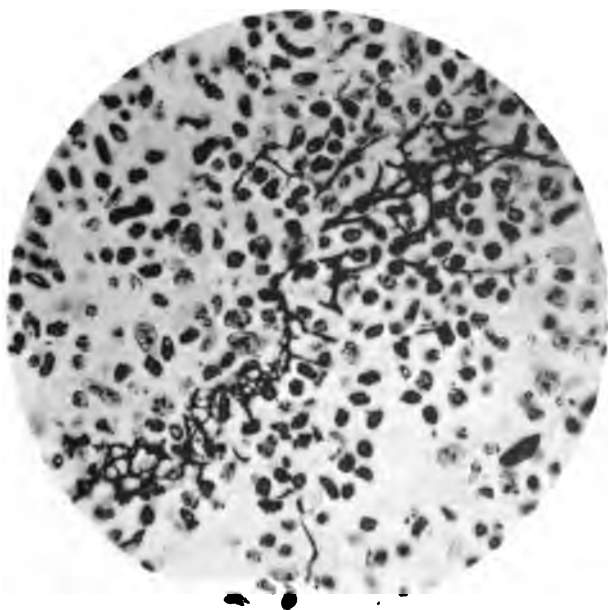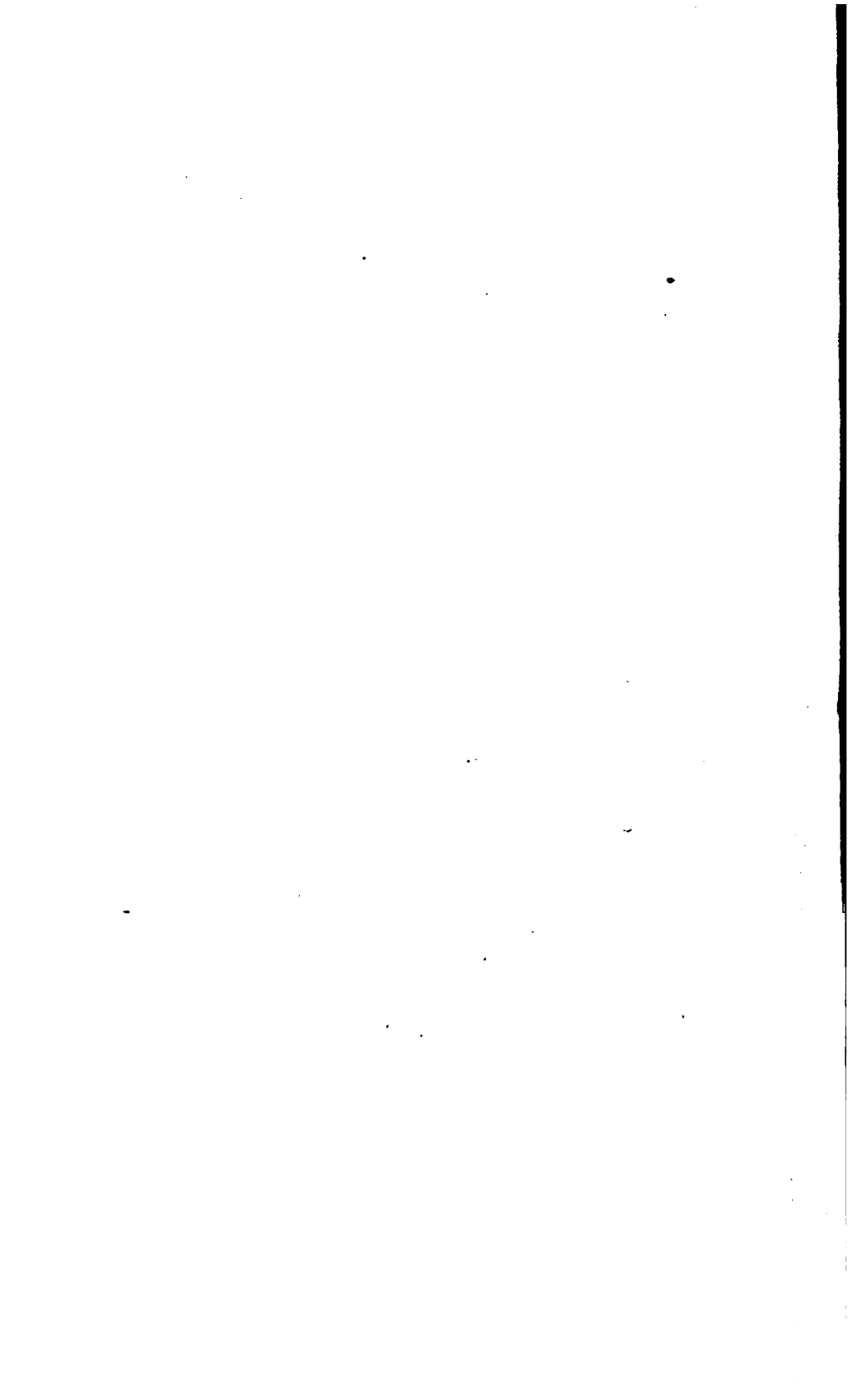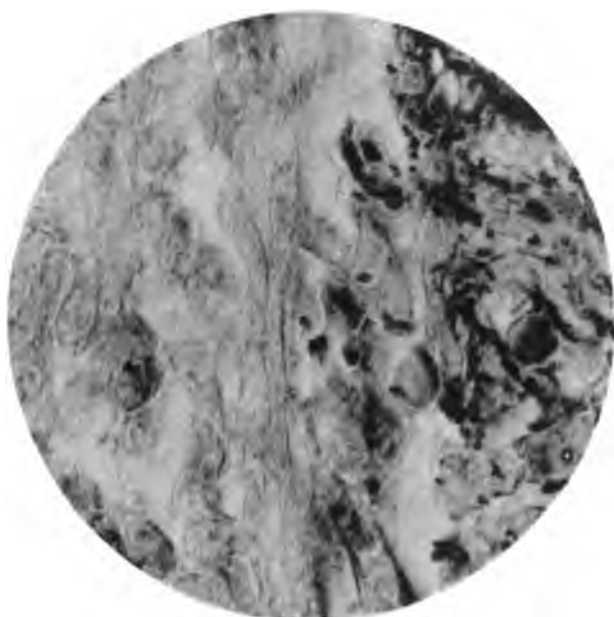
Fig. 1.

Fig. 2.

Fig. 1.
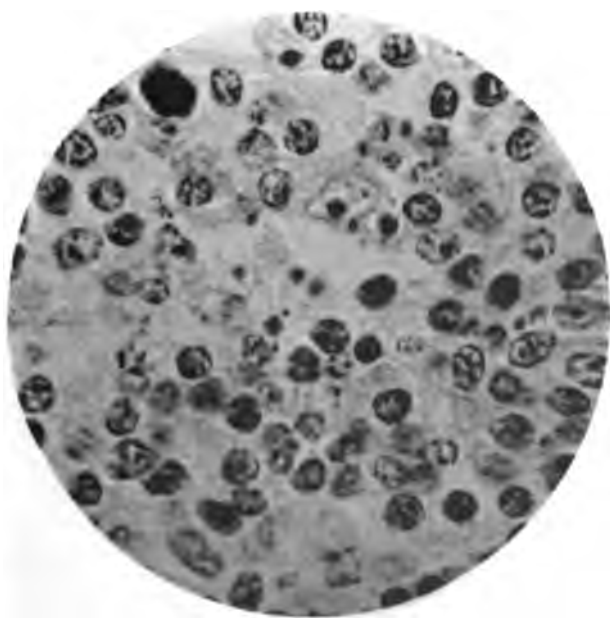
Fig. 2.
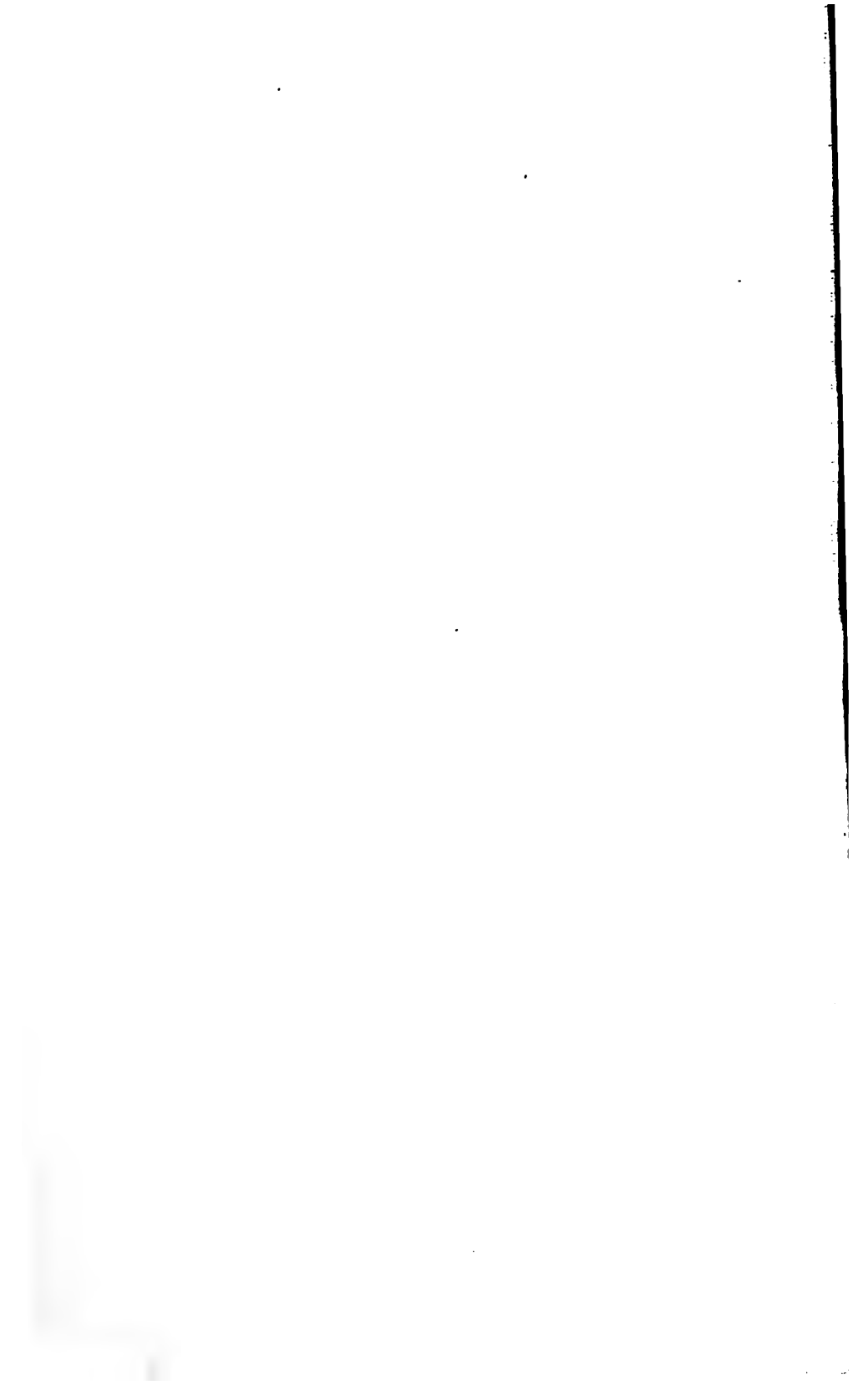
SUBSTITUTES FOR TUBERCULIN AS A MEANS OF DIAGNOSIS.

By RICHARD C. CABOT, M.D.,

Physician to Out-Patients at the Massachusetts General Hospital,

AND

J. J. WHORISKEY,

Student at the Harvard Medical School.

Objections are sometimes made to the use of tuberculin as a means of diagnosis. Personally these objections do not seem to me well founded, but the mere existence of such objections is enough to make us welcome any substitute for tuberculin which will accomplish the same ends for diagnosis and yet be beyond any question harmless.

French writers (Sirot, Hutinel, and others) have recently claimed that a reaction similar to that seen after tuberculin injections could be obtained by the use of a simple salt solution. In using such an artificial serum as is ordinarily made up for therapeutic infusion these writers assert that a rise of temperature occurred in the tubercular cases, and not in others. The solution used was made as follows:

Sodic chloride	5.
Sodic sulphate	10.
Distilled water	1000.

From 15 to 20 c.c. of this solution is injected subcutaneously under antiseptic precautions and the course of the temperature watched for the succeeding 24 hours.

1. Control Cases.

We tried this at my clinic at the Massachusetts General Hospital last summer. First I was injected myself and then 11 of the assistants at the clinic. The pain was very slight after the first prick from the needle.

Two of us had a maximum temperature of 99°, one of 99.1°, and one of 99.2° in the course of the next 24 hours. In the rest no rise occurred. No subjective discomforts were experienced.

2. *Tubercular Cases.*

Five cases of pulmonary tuberculosis — afebrile, and not advanced — were injected in a similar way. Three of them did not react at all, and the other two showed only 100° and 100.2° respectively, without any subjective discomforts.

Cases of bronchitis, malaria, enteritis, debility, and pleural effusion were also tried. None showed any reaction.

Total: 23 cases, injected with saline solution, all negative.

Somatose.

In an article by Matthes,[1] in 1894, the use of albumose in place of tuberculin as a means of diagnosis was first suggested and considerable success with it has since been reported.

In investigation along this line 11 cases were accordingly tested by us by injecting 1.5 c.c. of an aqueous solution of somatose. In 6 cases a 1 to 100 solution was used, and in 5 cases a 1 to 30 solution. The results are shown in the following tables:

Somatose Cases (dose, ¼ grain).

Name.	Diagnosis.	Injection.	Temperature before injection.	Temperature after injection.	Remarks.
James F....	Phthisis...	¼ grain	98.8	102°	Maximum temperature nine hours after injection.
Con. L....	" ...	"	98.4	102°	Maximum temperature ten hours after injection.
John M....	" ...	"	97.4	100.4°	Maximum temperature three hours after injection.
Thomas S..	" ...	"	99°	103.8°	Head-ache, back-ache, nausea, etc., with the fever.
Sam. K....	" ...	"	98.5°	102.5°	
W. J.C....	" ...	"	98.5	105°	Chill, nausea, head-ache, sweating.
R. D.......	" ...	"	98.4	99.	Reacted to tuberculin later.

[1] Ref. in Centralb. für innere Med., 1895, p. 386.

Somatose Cases (dose, ¾ grain).

Name.	Diagnosis.	Injection.	Temperature before injection.	Temperature after injection.	Remarks.
A. C........	Phthisis...	¾ grain	92.2	99.8	No subjective discomforts.
E. W......	" ...	"	99°	100°	No symptoms. Tuberculin produced a marked reaction.
R. L.......	" ...	"	98	100.6	No symptoms or discomforts. Negative reaction (?). Reacted to tuberculin.
G. B.	" ...	"	98.8	102.2°	
M. L.	Debility...	"	99°	99.8	
R. C. C.....	Healthy ..	"	98.6	98.7	

As will be seen from these tables, ⅚ of the phthisical cases which received the ¼-grain dose reacted positively, while most of those receiving the larger dose, ¾ grain (the solution being more concentrated, though the same volume was injected) did not react.

In connection with these cases, and as a control, 21 were injected with tuberculin. The patient was first ascertained to have no daily rise in temperature by giving him a thermometer which he took with him from the Out-Patient Department and held in his mouth for 6 minutes once in 4 hours, making no attempt whatever to shake it down or to read it. Next morning the patient presented himself at the Out-Patient room with his thermometer. Under such conditions the position of the mercury column represents the highest point to which the temperature has risen within the last 24 hours. This is the fact that we want to learn, and we can get as well with out-patients as when close watching is possible.

The *malaise*, head-ache, etc., which usually accompany the rise of temperature do not produce greater discomfort than can be safely borne by out-patients, provided they are warned of what is in store for them.

Among the 21 patients to whom we gave tuberculin were many doubtful lung cases, and various types of bone and gland tuberculosis referred from the surgical rooms. In almost every case the test was of distinct value in the diagnosis and so in the treatment.

In no case was the result of the test contradicted by the clinical course.

Conclusions.

1. The tuberculin test in cases of doubtful tuberculosis can be safely and efficiently carried out under the conditions existing at the out-patient department of a hospital.

2. The substitution of sodium chloride and sodium sulphate solution proved, in my hands, a total failure.

3. The use of somatose, while somewhat more successful than that of salt solution, and while deserving of further study, has not shown that the regularity of its action is at all comparable to that of tuberculin.

THE MINOT–BLAKE MICROTOME.

FRANCIS BLAKE, ESQ.

The somewhat novel form of microtome which I have the honor to present to you this evening is the outcome of my efforts to correct what I believe to be mechanical defects in the design and construction of its prototype, the Minot Wheel-Microtome, with which instrument you are all, of course, perfectly familiar. Ignoring certain minor variations in design, it may be said that the only substantial difference between the two instruments is in the methods used for supporting and guiding those structural parts by means of which the specimen to be cut is moved in a vertical and a horizontal direction. For this reason I have, with Dr. Minot's approbation, named this mere variation of his beautiful invention the Minot-Blake Microtome.

In the Minot Microtome the above-mentioned moving parts are supported and guided by an adjustable "gibbed" mechanism, of which the lathe slide-rest is a familiar example. It is obvious that with such mechanism there can be free movement only when there is a slight play between the parts; and experience has shown that the play which exists under the best adjustment precludes the cutting of satisfactory sections less than three and one-third microns in thickness.

In the Minot-Blake Microtome each of these moving parts has only three bearing points (forming the apices of a triangle), and is held in contact with its guiding surfaces by the action of a strong flat steel spring. The points which form the base of the triangle are V-shaped, and are held in contact with a V-shaped groove, while the third point is a flat block held in contact with a plane surface. This tripod bearing assures absolute stability under contact; and the stiff but yielding bar-spring assures absolute contact and compensation for wear. Broadly speaking, this mechanical arrangement is not novel. It was used by Sir William Thomson —

now Lord Kelvin — more than thirty years ago; and then enabled him for the first time, as he remarked, " to pick a thing up and to put it back just where he took it from " — a simple statement of the solution of one of the most difficult problems in the mechanic art. More recently a similar arrangement was used by Dr. T. C. Mendenhall in an apparatus built under his direction as Superintendent of the United States Coast and Geodetic Survey.

This microtome has been in constant use at the Pathological Laboratory of the Massachusetts General Hospital for nearly a year; and during this time it has preserved its adjustments and has proved its ability to cut satisfactorily single-micron sections in series. Its success, in this regard, is largely due to the ingenuity and the skilful manipulation of our co-member, Dr. James H. Wright. Indeed, a substantial improvement, in the matter of bracing the knife, has been made at his suggestion.

Looking at the instrument a little more in detail, you will note that the feed-wheel is of steel, seven inches in diameter, and cut to five hundred teeth. The micrometer cross-feed screw is of half a millimetre pitch, so that a single tooth of the feed-wheel advances the specimen one micron toward the knife. By a familiar adjustment the cross-feed may be varied from one to ten microns. The vertical movement is one inch.

I have here a change feed-wheel, cut to one thousand teeth, which can readily be applied to the instrument, with a resulting single-tooth feed of half a micron. This feed has as yet never been tried, but I have faith that the ingenuity and the beautiful manipulation of Dr. Wright will establish its practicability during the present year.

In conclusion I will say that as this unique experimental instrument is the product of my own laboratory, and largely the work of my own hands, it naturally is not just what it should be if it were to be offered as a commercial microtome. As an amateur mechanic — at the outset absolutely ignorant of your professional requirements — it has been my privilege to become, for the time being, a disciple of our " Micro-

tomic Master," Dr. Charles Sedgwick Minot; and my humble
labors have been amply rewarded by an assurance that their
results have been of some service to the noble profession in
which you are engaged. To that profession all that I have
done is hereby freely dedicated.

JANUARY 17, 1899.

[*Note by the Editor.* — As may be inferred from the foregoing paper,
Mr. Blake has no inclination to exploit the Minot-Blake Microtome as a
commercial instrument. He has, however, at the earnest request of a
number of the members of our Society, consented to supervise the construc-
tion of a dozen instruments, provided there is a demand for them. If the
instrument were to come into general use it could probably be sold for
$60; but the cost of the first dozen instruments — including pattern-
making — would probably be about $100 each.

It should be understood that even with this instrument the cutting of
one-micron sections involves a technical skill which cannot reasonably be
looked for in ordinary laboratory practice. Having given this *warning,* —
so to speak, — the Editor expresses his readiness to receive conditional
orders from those who wish to possess reproductions of the Minot-Blake
Microtome.]

[The Microtome and its working was demonstrated by Dr. Wright
after the meeting.]

DESCRIPTION OF PLATES.

The three half-tone plates which illustrate Mr. Blake's paper are from photographs kindly furnished by Dr. J. H. Wright, Director of the Pathological Laboratory of the Massachusetts General Hospital. While they are in general sufficiently explained by the text of the paper, it may be noted that the tripod method of support, as applied to the knife-carriage and the knife-brace, as suggested by Dr. Wright, are clearly shown in Plate No. 1.

PLATE I.
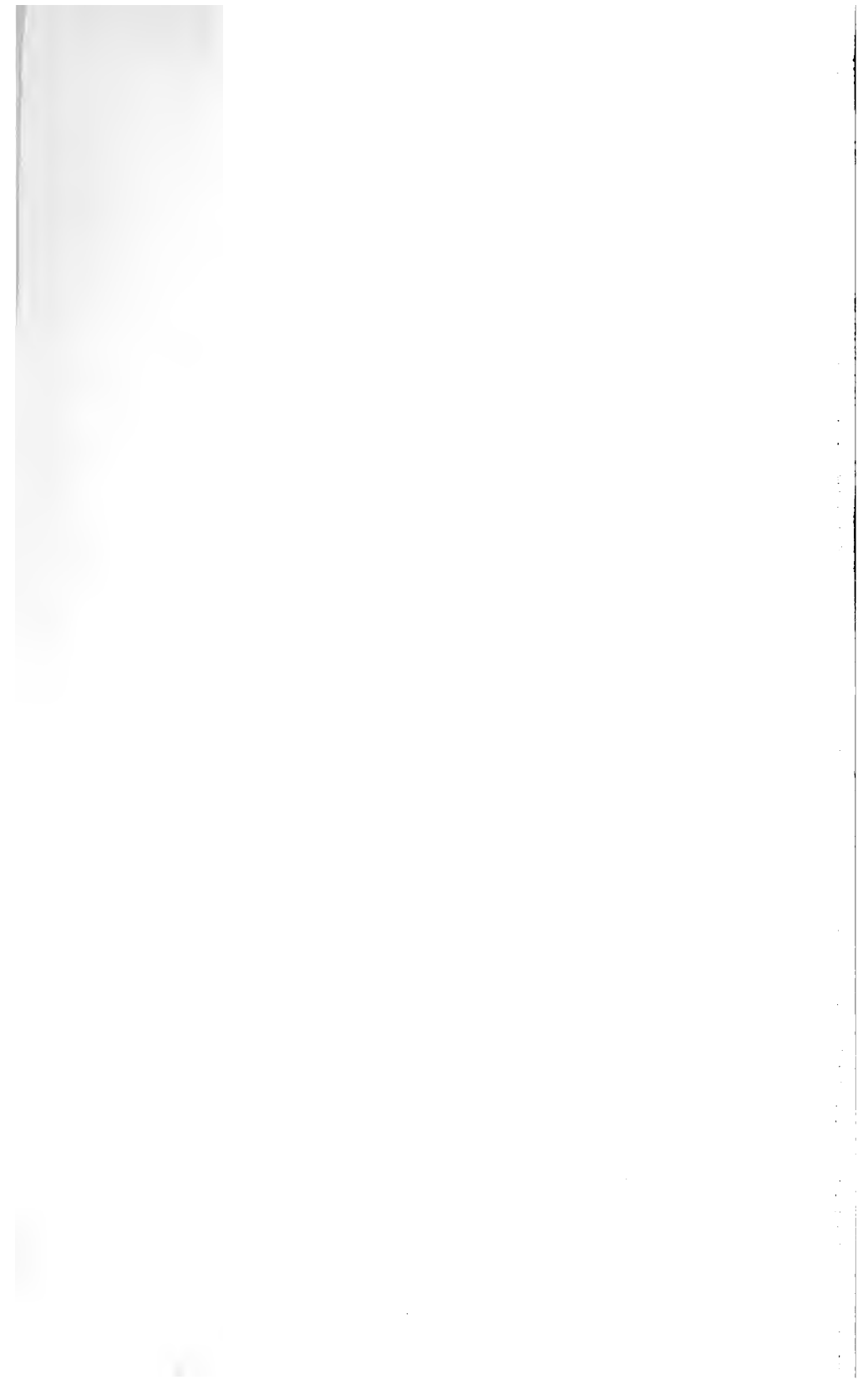
Plate II.
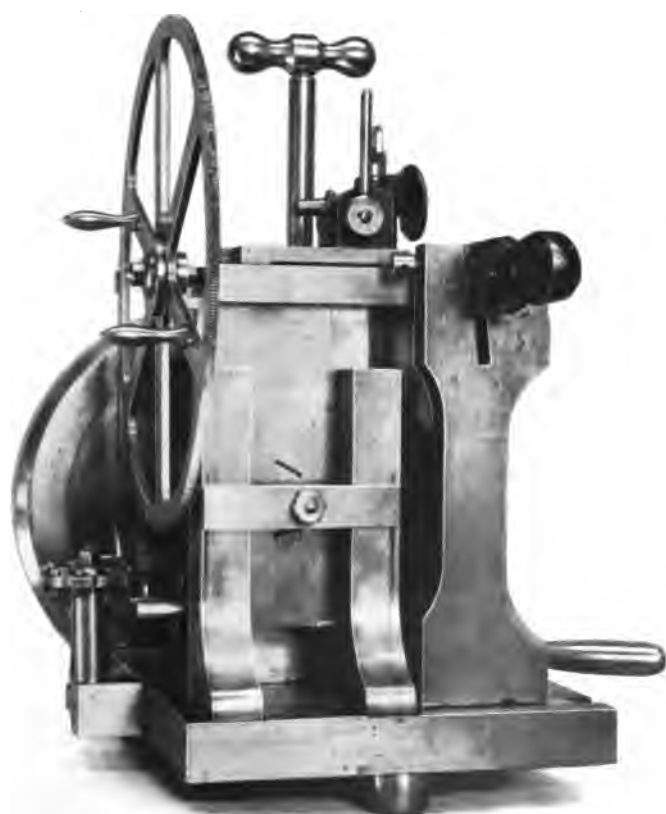
PLATE III.

ON THE RÔLE OF BACTERIA IN THE FORMATION OF GALL–STONES.

MARK W. RICHARDSON.

From the Pathological Laboratory of the Massachusetts General Hospital.

The relation of bacteria to the formation of biliary calculi is a theme which has, during the last decade, interested a number of investigators, especially in France.

Our present knowledge of the subject may be summed up as follows :

I. Bacteria have been demonstrated, either by culture or cover-glass preparation, in the centres of a considerable proportion of the gall-stones examined. The bacillus coli communis and the typhoid bacillus have been the organisms most commonly found.

II. There is said to be a close relationship between typhoid fever and subsequent development of gall-stones.

III. It is claimed that by injecting bacteria into the gall-bladders of animals sufficiently typical calculi can be produced.

The communication made by the writer is one distinctly preliminary in character, and has to do with the experimental production of gall-stones in rabbits.

The circumstances leading up to the experiment were the following :

In a case of cholecystitis operated on by Dr. M. H. Richardson the typhoid bacillus was found, most unexpectedly, in the exudate. Moreover, the microscopical examination of the fluid from the gall-bladder showed not only that many bacilli were present, but also that they were collected together in large clumps, as if a gigantic serum reaction had taken place in the gall-bladder. The possibility was suggested that these large clumps of bacilli would offer an excellent nucleus for the formation of calculi — a theory, it was afterward learned, which had occurred quite independently to Dr. Harvey W. Cushing, of the Johns Hopkins Hospital.

Furthermore, in this connection the following observations are of interest: The bile was examined at autopsy in six cases of typhoid fever, and in five, large clumps of typhoid bacilli were to be seen. The absence of the clumps in the sixth case seemed unusual, until it was found that in this case the blood during life and after death had shown no clumping power. These facts are of importance, of course, in establishing a possible relation between typhoid fever and biliary calculi.

It was next to be seen whether experiment would in any way bear out this theory. For this purpose three rabbits were taken.

Rabbit No. I. — After laparotomy there was injected into the gall-bladder ½ c.c. of a typhoid bouillon culture which had been clumped by the addition of serum from a typhoid patient. The gall-bladder was found previously to be free from stones.

Rabbit No. II. — After laparotomy two drops of an ordinary bouillon culture of typhoid bacillus was injected into the gall-bladder.

Rabbit No. III. — Control animal.

The animals were placed in cages and fed as usual, except that calcium phosphate was mixed with their food, in order that the formation of calculi should not fail from the lack of lime salts, at any rate.

About four months later all three rabbits died.

Autopsy showed in the gall-bladder of the control rabbit a number of small rounded bodies the size of a pin's head. These crushed readily under cover glass, and then showed arrangement of their substance in concentric rings.

The gall-bladder of the rabbit which had received the plain bouillon culture showed nothing unusual.

In the case of Rabbit No. I., however, where the clumped culture was introduced, the gall-bladder was contracted about a rounded body, firm in consistency, brown in color, and about the size of a pea-bean.

The cultures from the organs were unsatisfactory, and without value, inasmuch as the animals died in midsummer,

while the writer was away, and two days had elapsed when they were examined.

The result of this experiment is to be regarded as suggestive only.   Much more extended observation must be made before it can be said that this theory of the formation of gall-stones has any real foundation in fact.

PLATE I.

FIG. 1. — Shows about one-half of liver with gall-bladder of Rabbit No. 1
(natural size).   Calculus is seen lying in gall-bladder.

FIG. 2. — Same, with calculus removed from gall-bladder.

Fig. 1

Fig. 2.

Richardson.

RABIES IN THE VICINITY OF BOSTON.

LANGDON FROTHINGHAM, M.D.V.

Since March, 1897, I have been Pathologist to the Massa-
chusetts Board of Cattle Commissioners, and one of my duties
has been to establish the presence or absence of rabies in
such suspicious cases as have been sent to the Board.

It should be borne in mind that the etiology of rabies is
still unknown, and also that there are no typical post-mortem
lesions present in animals that have died of this disease, —
nothing that justifies such a diagnosis from the autopsy alone;
indeed, absolutely negative findings may be looked upon with
suspicion. It is, therefore, necessary to resort to other means,
and the only accurate method known seems to be that recom-
mended by Pasteur; namely, the subdural injection of rabbits
with a suspension of the brain or spinal cord of the suspected
animal.

The suspension to be injected is made by crushing a small
portion of the brain or cord in a mortar and adding to this a
sufficient quantity of sterile water or bouillon. The rabbit to
be inoculated is etherized, a short longitudinal cut made
through the skin of the forehead, the periosteum reflected,
and a small disk of bone lifted with a trephine, thus exposing
the dura. Beneath this a few drops of the brain or cord sus-
pension is injected with a hypodermic syringe. The wound
in the skin is then sutured, and if the whole operation has
been successful the rabbit acts in a perfectly normal manner,
after the influence of the anesthetic has passed away.
Throughout the operation aseptic precautions are, of course,
observed.

In this manner I have injected rabbits from 30 suspicious
cases of rabies, of which 20 have proved positive. In rabbits
inoculated from cases of " street rabies " the symptoms appear
in from 10 days to 3 months. The symptoms are invariably
those of paralysis, beginning in the posterior extremities and
gradually passing forward till general paralysis ensues, death

taking place in from 24 hours to 7 days after the first symptoms have been observed.

The virus of rabies is easily destroyed by heat. On the contrary, it seems to withstand cold for an indefinite period. Jobert found that a cord kept frozen at a temperature of from minus 10° to minus 20° C. for ten months was still virulent. The suspensions of brain or cord used in this work I have kept in test tubes at a temperature varying but little from 25° F., my object being to ascertain how long the virulence would be retained under these conditions. An inoculation was recently made with the suspension of Case 1 (see table), which had been frozen for about 1 year and 10 months. The rabbit developed the usual symptoms of rabies in 18 days, showing no loss of virulence during this long period of freezing.

The following table gives the number of positive cases since March, '97, which have come under my observation :

<div align="center">RABIES.   FROM MARCH, 1897, TO DECEMBER, 1898.</div>

ANIMAL.	Town.	Rabbits inoculated.	Time elapsed from inoculation to appearance of first symptoms of rabies.[1]
1. Newfoundland dog..	Holyoke	March 24, 1897	13 days
2. Pug dog...........	Lynn..........	June 4	12 "
		June 4	15 "
3. Cow	Holyoke	August 31	21 "
4. French poodle......	Melrose	November 13	16 "
		November 17	36 "
5. Fox hound.........	Sudbury	November 30	22 "
		November 30	24 "
6. Irish setter.........	South Braintree.	December 30	14 "
		December 30	14 "
7. Bull dog...........	Lynn..........	January 1, 1898	16 "
8. Cocker spaniel	Lynn..........	January 6	13 "
9. Chinese dog (?)....	Melrose	January 27	16 "

<div align="center">[1] Average, 16 days.</div>

RABIES. FROM MARCH, 1897, TO DECEMBER, 1898. — *Continued.*

ANIMAL.	Town.	Rabbits inoculated.	Time elapsed from inoculation to appearance of first symptoms of rabies.
10. Horse.............	Salem	February 3	13 days
11. Mongrel dog.......	Lynn..........	February 8	14 "
		February 24	15 "
12. St. Bernard dog	Swampscott	March 14	15 "
13. Mongrel dog.......	Lynn..........	March 21	10 "
14. Mongrel dog.......	Lynn..........	March 21	11 "
15. Skye terrier........	Watertown.....	April 16	21 "
16. Cat ....:..	South Braintree.	October 4	14 "
		October 4	14 "
17. Boston terrier	Boston	October 12	12 "
18. Dog (Pointer)	Dracut	October 28	17 "
19. Collie	Newton Centre..	October 22	18 "
		October 24	16 "
20. Black and tan	Lowell	November 22	13 "
		November 22	12 "

BRANCHING FORMS OF BACILLUS DIPHTHERIÆ.

HIBBERT WINSLOW HILL, DIRECTOR.

(Preliminary Note from the Laboratory of the Boston Board of Health.)

The researches of Nocard and Roux, Metschnikoff, Klein, Mafucci, Fischel, Koppen Jones, C. Fraenkel, v. Babes, Craig, and others during the last thirteen years have established the fact that some of the organisms generally classed as bacilli, and consisting, therefore, by definition, of unbranched cells or chains of cells, occasionally show individuals which branch very distinctly. Amongst the forms in which branching has been observed are the bacillus tuberculosis, the bacillus tuberculosis gallinarum, the bacillus lepræ, and the bacillus diphtheriæ.

The interest which attaches to these demonstrations is almost wholly morphological and botanical. The elementary definitions or the general classifications of bacteriology may be affected, but accepted beliefs concerning the etiological relations of the organisms involved to pathological conditions remain unchanged.

The belief that the organisms now known as the bacillus tuberculosis and the bacillus diphtheriæ, at least, should be placed amongst the streptothricheæ has been gaining ground for some time as a result of these investigations. This is especially true of the former organism. Having observed branching forms of diphtheria bacilli in a number of different cases of the disease, I contribute these notes as additional evidence pointing to the advisability of definitely recognizing the latter organism also as a streptothrix.

I obtained my first branching culture in 1895. Unfortunately, circumstances prevented full investigation, and it was not until August, 1898, that I again observed this peculiarity. From the latter date to the end of the year four distinct cultures were obtained from the throats of different patients. Only two of these cultures have been

properly isolated and examined: one obtained in August and here designated "Golden," the other a culture obtained early in December and designated "Laffran." The two cases from which these cultures came agree in that the cultures were taken from the throat, in that membrane was present, and in that the attending physician believed the attack to be diphtheria. In each case I obtained only one positive culture, both cultures within a day or two of the date of the earliest symptoms. In one (G) I obtained a negative culture also sixteen days after the positive culture. The other (L) was removed to the City Hospital and there ran a typical course, ending in practical recovery about the end of December under the care of Dr. McCollom, who informed me that the patient afterwards showed some slight post-diphtheritic paralysis.

In general terms the same description will apply to both of these cultures. Both were isolated by the method of dilution in streak cultures on slanted blood serum, and also by plating out on glycerine agar. Neither showed any unusual macroscopic peculiarities of growth on agar, broth, potato, or serum. From the first three of these media the bacilli presented a morphology perfectly characteristic of ordinary diphtheria bacilli grown on such media. In the fermentation tube, containing 1 % dextrose broth, the growth was confined to the bulb. The initial acidity to phenolphthalein of the broth was + 15 on Fuller's Scale, or 1.5 %. After three days' growth at 37° C. the reaction of the bulb was + 35 or 3.5 % acid. The reaction of the closed branch remained unchanged. (+ indicates acid; — = alkaline.) Old cultures become alkaline. On serum the bacilli presented an exaggeration of the ordinary morphological peculiarities characteristic of this medium. The individual rods were slightly larger than usual, slightly more irregular, and contained granules more distinctly developed. They were non-motile and yielded typical staining reactions. The serum cultures, however, showed, besides these well-marked but not extraordinary characters, the presence of branched forms; that is, of individual rods lying in such close and definite

relation to each other that the possibility of accidental appo-
sition could not be entertained as an explanation for the
appearances they presented even in stained preparations.
When these forms were carefully watched in hanging drop
preparations, and induced to roll over by appropriate manipu-
lations of the liquid, the existence of actual union at the
points of contact was verified by the observation that both
stem and branch moved together as one piece.

The form most frequently presented by these branched
bacilli is that of a tri-radiate star. In many instances one of
the radiating branches gives rise to two others, thus presenting
five individual rods connected together. In one instance a
single rod of considerable length was observed giving rise to
three branches, all springing together from a single point
situated at one end of the middle third of the main rod.
There are also other and less frequent variations. The indi-
vidual sections composing a branched form usually show all
the peculiarities of staining, the presence of granules, swol-
len ends, unstained spaces, etc., which the unbranched forms
in the same culture present.

It is especially interesting to note that in some preparations
almost all, and in almost all preparations some at least, of the
branching forms present a granule in every way similar to
the ordinary granules of diphtheria bacilli, situated at the
point from which the branches originate.

The virulence of the cultures containing branched forms
was tested by inoculating guinea pigs, both with twenty-four-
hour broth cultures grown at 37° C. (5 % of the body-weight),
and with growths from solid media. The Golden culture was
tested within a week of its isolation and again four months
later. In both instances this culture proved fatal within two
days, the animal showing those lesions which one would
expect from the injection of ordinary diphtheria cultures.
From both animals the organisms were recovered after
death, and both the recovered cultures branched on blood
serum as before. The Laffran culture was also tested twice
and acted in a precisely similar manner. The bacilli did not
branch in the living guinea pig, nor on normal tissues re-

moved from the guinea pig under precautions to insure sterility and afterwards inoculated with pure cultures.

The branching is found principally on blood serum. White of egg mixed with an equal quantity of water, and coagulated in tubes exactly in the same way as blood serum, yielded a growth in which the rods were small, and branching forms, although present, were infrequent.   On egg, hard boiled in the shell, branching was very infrequent.   In liquid blood serum some branching has been observed.   As already stated, branching does not in recent cultures occur on the other media so far tried, nor in the water which collects at the lower end of serum tubes.   Agar cultures may show branching after ten days' growth.

Both the Golden and Laffran cultures present remarkably numerous, large, and well-stained granules.   It is interesting to note that the granules in preparation, stained only with Löffler's methylene blue, are red or purple-red, while the rest of the rod is blue.   This is true not only of these two cultures, but in my hands at least of almost all primary diphtheria cultures as they are sent in by physicians.   This peculiar metachromatic staining was first pointed out to me by Bolton in Philadelphia, in 1896, and he then offered as an explanation the supposition of a German investigator, who held that the granules consisted of some substance allied to amyloid, and that the red tint was the result of the well-known affinity of amyloid tissue for methyl violet and gentian violet, which latter stains may be present in the purest forms of methylene blue to a slight extent.   Dr. Ernst furnished me with a sample of Löffler's methylene blue which is believed to be exceptionally pure.   In my hands, however, this stain also colored the granules purple-red, although, so far as I have tried it, the red is less distinct than it is in specimens treated with my own Löffler stain.

The degree of stability of the characteristics described is shown by the fact that five consecutive transplantations of one culture on serum, and of eight the other, had little appreciable effect other than in diminishing the percentage of branching forms found.   On plating out the later transplantations on

glycerine agar, however, serum cultures from the plates presented an extremely high percentage of branched forms.

I hope to continue this investigation in order to determine the following points:

1st. The nature of the branching. I wish to be understood as having used this word hitherto in a descriptive rather than in a technical sense. The development of the branches may be followed in hanging drop preparations, using sterile liquid blood serum as a medium.

2d. The nature of the granules, and especially their relation to the development of the branches.

3d. The relation of branched to unbranched forms. It is probable that the ordinary diphtheria bacillus will eventually be accepted as a variation or degeneration of a higher type of plant than the bacillus proper. Sometimes the branching resembles the branching of a cladothrix more often than that of a streptothrix. On the other hand it is possible, although improbable, that the branching may be apparent only, depending simply on some peculiar condition of the external layers of the cell, which, in turn, may be a result of degenerative changes. The ordinary bacillary forms would then be the higher type, the branched forms the lower. The supposition that the granules are spores, or spore-like bodies, is probably quite untenable; nevertheless it need not be forgotten that appearances similar to some of those observed above might result from the vegetation of a spore while still contained in the parent body, although no analogous condition is known as occurring in bacteria, so far as I am aware. The possibility that the branching might be due to some peculiarity in the serum made in the Health Department Laboratory is ruled out, I think, by the fact that serum tubes furnished to me by Dr. Councilman, by Dr. Ernst, and by Dr. Wright all yielded branching forms when inoculated with these cultures.

4th. The exact determination of the toxicity of these forms.

5th. The determination of the percentage of cases of diphtheria in which branched forms occur. Since Jan. 1,

1899, a definite search for branching forms has been carried out in every positive culture received in the laboratory. I have been able to convince myself that decidedly more than fifty per cent. of these (including both primaries and secondaries) contain at least a few branching diphtheria bacilli. Personal inquiry amongst observers engaged in constant examination of diphtheria cultures for diagnostic purposes confirms my own observations. It occurred to me to look over such photomicrographs of diphtheria organisms supposed to represent typical cultures as were available. In a number of these also I was able to recognize forms resembling those which, in my preparations, I consider branched. The plate from Fraenkel and Pfeiffer, reproduced in the text-book of Mallory and Wright, shows one such form about the centre of the field. That reproduced in Sternberg's Manual shows two or three branching forms. I believe this condition to be much more common than is generally supposed, and that therefore the evidence in favor of classing this organism as a streptothrix is proportionately strong.

In conclusion I wish to thank Dr. Ernst for his kindness in having the accompanying drawings made for me in his own laboratory.

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DESCRIPTION OF PLATE.

FIG. 1.　Branching forms of b. diphtheriæ, from "Golden" culture on Löffler's blood serum. The preparation is stained with Löffler's methylene blue only. The dark masses are red or purple; the rest of the rod blue.

FIG. 2.　Branching forms of b. diphtheriæ, from "Laffran" culture on Löffler's blood serum, similarly stained.
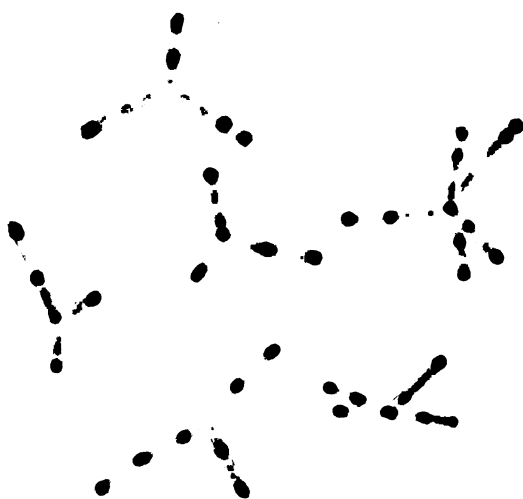
FIG. I.
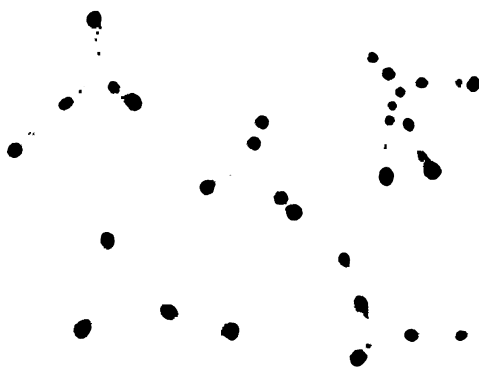
FIG. II.

THE PRIMARY INFECTION IN ACUTE SUPPURATIONS OF THE TYMPANUM.

J. ORNE GREEN, M.D.

My object was to ascertain the original infection of the tympanum before an opening in the drum-membrane had exposed the cavity to invasion from the meatus. For this purpose I have tabulated the results of bacteriological examination in 101 cultures made from the first drop of pus evacuated after paracentesis of the drum-membrane in acute suppuration of the tympanum. The examinations were made in the laboratories of the Boston City Hospital and of the Massachusetts Eye and Ear Infirmary, and to the pathologists of those institutions, and their assistants, I am indebted for the reports. The cases selected were all acute suppurations requiring paracentesis for evacuation of secretion and relief of pain. The meatus was first cleansed by syringing with corrosive-sublimate solution $\frac{1}{5000}$; the meatus and drum-membrane were then scrubbed with cotton dipped in corrosive-sublimate $\frac{1}{2000}$, and the parts carefully dried with sterile cotton. In many cases as an additional precaution the meatus was swabbed out with alcohol 95 per cent. Aseptic precautions in regard to instruments were always used. After opening the drum-membrane either the first drop of pus which exuded was taken or the inoculating wire was passed through the opening directly into the tympanum.

The reports were as follows:

Pneumococcus (micrococcus lanceolatus) . . . alone	10	
" with staphylococcus		4
Streptococcus . . . . alone	19	
" with staphylococcus aureus		11
" " " albus		2
Staphylococcus albus . . . . alone	8	
" " with streptococcus		2
" " " bacillus diphtheriæ . . .		2
" aureus . . . . alone	9	
" " with streptococcus		11

Staphylococcus aureus with bacillus diphtheriæ . . .   2
       "   (variety not stated) . . . . . alone   19
       "   with pyocyaneus   1
       "   " pneumococcus   4
Bacillus diphtheriæ . . . . alone   2
     "   "   with staphylococcus albus   . . .   2
     "   "   "   "   aureus   . . .   2
Bacillus pyocyaneus . . . . alone   3
     "   "   with staphylococcus   1
A capsule bacillus . . . . alone   3
No growth (probably faulty culture)   4
                                                 ——
                                                 73

In 73 out of the 101 cases pure cultures were reported, viz. :

Staphylococcus (albus 8, aureus 9, variety not stated 19)   .   36
Streptococcus   19
Pneumococcus   10
Bacillus diphtheriæ   2
Bacillus pyocyaneus   3
A capsule bacillus   3

This leaves 28 cases of mixed infection (28 per cent.). In the table the mixed infections are classified under the predominating growth.

Some years ago it was thought from the German investigations that the original infection in these cases was by the pathogenic organisms,— pneumococcus, pneumobacillus, and bacillus diphtheriæ, — and that the pyogenic microbes only appeared later, often entirely supplanting the pathogenic germ. Some of my first cultures proved the presence of pyogenic organisms in the very earliest stages of the disease, and I very soon completely satisfied myself that this was the fact by a careful selection of cases and extra precautions in the cultures.

The capsule bacillus reported in three of the cases, and, since these statistics were compiled, also reported in several other cases, could not be classified with certainty.   Dr. J. J.

Curry, formerly of the City Hospital laboratory, states[1] that, although resembling the bacillus of Friedlander, it grew on artificial media with a capsule surrounding it, and differed also in other minor points. He considered it identical with the capsule bacillus described by Wright and Mallory.[2]

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[1] Med. and Surg. Reports of the Boston City Hospital, 8th series, 1897.
[2] Centralblatt f. Bacteriologie, 1895.

THE BACTERIOLOGY OF MASTOIDITIS.

J. ORNE GREEN, M.D.

In mastoiditides that come to operation — the only cases where we are able to get cultures — the infection found is always liable to be a secondary and not the primary one, for the tympanum is always exposed to a fresh invasion from the meatus through the open perforation of the drum-membrane and from within through the Eustachian tube. The investigations of Bordoni-Uffreduzzi, Gradenigo, and Zaufal first proved that a pure infection often became a mixed one soon after rupture of the drum-membrane, and also that the primary organism might be entirely suppressed by a secondary one. Several years ago I was satisfied of both these facts: one of my early cases being one where the primary infection, as shown by a paracentesis, was pneumococcus, and later, a mastoiditis developing, the infection of that cavity was found to be staphylococcus.

The following table is compiled from 144 mastoid operations performed by various members of the staff in 1897 and 1898 at the Eye and Ear Infirmary, and published in the reports of that institution, and from 14 operations at the City Hospital reported by Dr. J. J. Curry.[1] The cultures were made from the interior of the mastoid, and represent the infection of the mastoid cavity at the time of operation.

The reports were as follows:

Staphylococcus		49
"	and pneumococcus	10
"	and streptococcus	13
"	and unknown bacillus	3
"	and bacillus fœtidus	3
"	and streptococcus and pneumococcus	3
"	and pneumococcus and bacillus fœtidus,	1
Streptococcus		31
"	and staphylococcus	13
"	and pneumococcus	3

[1] Med. and Surg. Reports, Boston City Hospital, 8th series, 1897.

Streptococcus and staphylococcus and pneumococcus .		3
Pneumococcus	23	
" and streptococcus		3
" and staphylococcus		10
" and bacillus fœtidus		2
" and staphylococcus and streptococcus .		3
" " " " bacillus fœtidus,		1
Pyocyaneus	8	
Bacillus diphtheriæ and a capsule bacillus		1
Large spore-bearing bacillus (unclassified)	1	

In regard to the large spore-bearing bacillus Dr. Curry says[1] that it closely resembled the anthrax bacillus in growth and size, but he found it non-pathogenic for guinea-pigs and rabbits, and was unable to identify it. He found it twice, once in the mastoid in the case above reported, and once in the tympanum combined with the staphylococcus albus.

A similar large bacillus was reported from three other mastoids in combination with staphylococcus at the Infirmary, and it has been reported in a few other cases from the tympanum, but no further attempts have been made to identify it.

This table is not without interest to the surgeon in showing that what are usually regarded as the less virulent microbes are capable of producing the more serious complications of an aural suppuration, the staphylococcus occurring nearly twice as often as the streptococcus (staphylococcus 49, streptococcus 31, pneumococcus 23). It also shows that from the variety of microbe, either primary or secondary in the tympanum, we are not justified in predicting the chances for or against a future mastoiditis. Nor does the variety of microbe help in deciding the prognosis: of the 144 Infirmary cases 7 died, viz., streptococcus 2, staphylococcus 3, streptococcus and staphylococcus 1, staphylococcus, streptococcus, and pneumococcus 1; i.e., the staphylococcus was equally fatal with the streptococcus.

In the tables of the Infirmary the results of the operation are given; and in 52 cases which recovered are given the

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[1] Op. cit.

number of days from the time of operation to complete recov-
ery; and I find the average number of days in

5 pyocyaneus cases was	. . . .	83
22 staphylococcus cases was	. . . .	58
6 staphylococcus and streptococcus cases was	. .	53
8 staphylococcus and pneumococcus cases was	. .	48
12 pneumococcus cases was	. . . .	39
. 9 streptococcus cases was	. . . .	36

i.e., the pyocyaneus cases were the longest, the staphylococcus
cases the next longest, and the streptococcus cases the short-
est of all.

I have considered the disease merely from the bacteriolog-
ical standpoint, and these figures show that we may have in
mastoiditis all of the more common varieties of microbes, that
the staphylococcus is much more common than the strepto-
coccus, and that, so far as the few fatal cases can prove any-
thing, they show that the staphylococcus is equally fatal with
the streptococcus. I do not myself believe that the special
variety of microörganism is of much importance in the dis-
ease. From a clinical point of view, vastly more depends on
the histological and anatomical peculiarities of the bone than
on the variety of microbe.

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on January 24, February 7 and 17, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

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688 Boylston Street,

Boston, Massachusetts, U.S.A.

$14,007$

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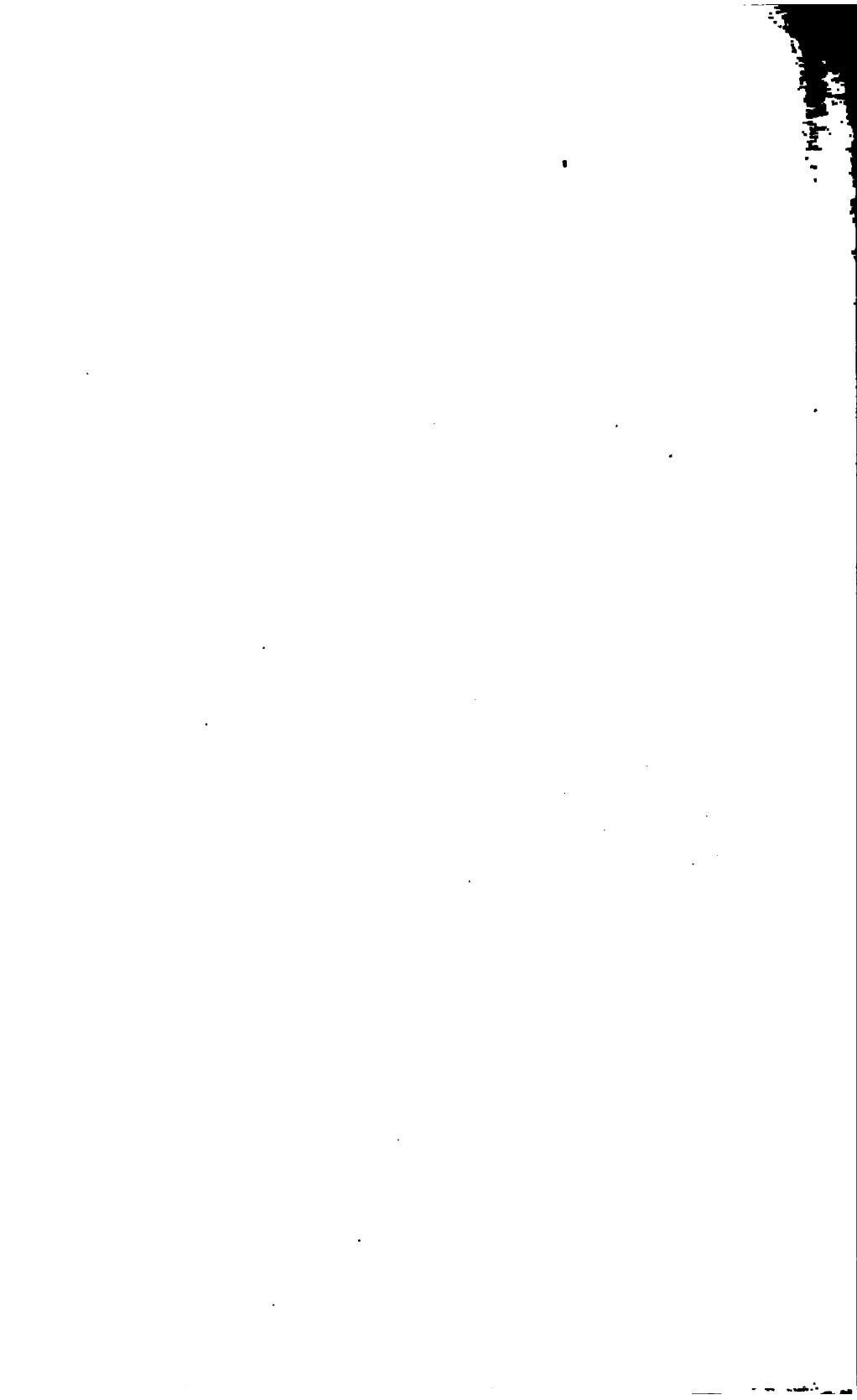
THE CHARACTER OF THE CELLULAR EXUDATION IN ACUTE KERATITIS OF THE RABBIT.

BY W. T. COUNCILMAN, M.D.

(Address delivered before the Chicago Pathological Society, Dec. 28, 1898.)

Those changes in tissue which follow an injury, and which in their entirety we call inflammation, have long been a favorite subject both for investigation and for theory. Almost all the old systems of medicine, based as they were on theoretical conceptions of disease, used the inflammatory processes to furnish proof of the correctness of the particular theory set forth. The real investigation of the inflammatory changes may be said to have begun with John Hunter. Hunter, Waller, Virchow, and Cohnheim are the names with which the great advances in our knowledge of the process have been associated. Ehrlich has indirectly contributed much in teaching the differences in the character of the leucocytes, and giving us methods by which they may be distinguished with more or less accuracy. The very slight contribution to our knowledge of the subject which I shall offer you to-night is the result of the study of a subject pursued very intermittently.

The cornea has been and must for some time remain a favorite tissue for experimental investigation for the patholo-

gist.   A review of all the articles written in the last forty years on acute inflammation of the cornea would carry us over the entire history of the various theories on the origin of the new cells in inflamed tissue.   Whatever theory was advanced, its upholders have found support in what they found in this tissue.   The illustrations which form a part of the numerous articles would fill a large volume.   They are in part objective, with the author's interpretations added to the objective features, and in part imaginary.   The reason that the cornea has been so generally selected for the study of inflammation lies in the great simplicity of the tissue and the absence of blood-vessels.   We know definitely the character of the cells which are normally present in the tissue, and knowing this it should be easy to determine the character and origin of the numerous new cells which are found in it when inflamed.   The tissue is also admirably adapted to the study of the character of the cell changes which are produced in tissue by the various bacteria.

The cornea is covered with several layers of epithelial cells differing neither in character nor arrangement from those covering the conjunctiva.   Below the epithelium is the proper tissue of the cornea, which agrees in its general features with the connective tissue.   It is made up of straight fibres which give the reaction of white fibrous tissue, and which are arranged in planes.   The fibres in these planes run in various directions, usually at right or oblique angles with the fibres in the overlying planes.   They are all straight, and all those in the same plane are parallel.   Between the fibres there is a general ground substance which stains brown with nitrate of silver.   In good nitrate of silver preparations of the cornea these fibres are not visible.   In preparations made from oedematous corneas, and when the tissue is slightly swollen in acid, the nitrate of silver solution penetrates between the fibres, forming brown lines.   The corneal corpuscles are connective tissue cells, flattened antero-posteriorly, which lie between the layers of the fibres.

In a properly prepared specimen stained with nitrate of silver there are numerous clear spaces which have extremely

irregular outlines, and which communicate by means of numerous processes with both the spaces on the same plane and those above and below. After staining the silver specimen with a nuclear stain, large, irregular, pale, or slightly granular nuclei are found in these spaces. Rarely two nuclei are found in the cell spaces. These are the nuclei of the corneal corpuscles, and the protoplasm of these fills the space. In gold preparations, in which all the protoplasm is stained, a protoplasmic network similar to the network of spaces in the silver cornea is seen.

In addition to the spaces in the tissue occupied by the corneal corpuscles, long spaces are seen which extend from the periphery to the centre, constantly dividing into smaller branches. The larger spaces show a tracery of silver lines similar to a lymphatic vessel. In the smaller spaces the lines are more irregular. These are the spaces in which the nerves run, and the corneal spaces open freely into them. The cornea has no blood-vessels or lymphatics, properly speaking, although the nerve channels, representing perineural lymph spaces, take the place of the latter. These nerve channels can be regarded simply as enlarged and elongated cell spaces lined on all sides by flattened corneal corpuscles similar to those in the tissue.

Other cells are found in the tissue in addition to the corneal corpuscles. In places an elongated protoplasmic thread resembling a nerve, but differing from this in the presence of a nucleus similarly elongated, is found in the tissue. These cells may be so outstretched as to extend entirely across the field of the microscope, and are parallel to the corneal fibres in the same plane. Or a round cell, with a curved irregular nucleus, is found in the same cell space, with a corneal corpuscle, or in the irregular space between two corneal spaces, conforming itself to the shape of this. These cells are most numerous in the upper layers of the tissue, and near the scleral margin. On an average not more than eight or twelve will be found in a thin section of the entire cornea. These are the wandering cells of the tissue described by Recklinghausen many years ago.

So much for the normal tissue. Inflammation may be produced in the tissue in a variety of ways, and the changes produced are alike in their general features, though they differ somewhat according to the degree of the inflammation and the character of the agent used to produce it.

From the many articles which have been written on this subject, though there are some contradictions, we can accept the following: In the inflamed cornea numerous new cells appear. These cells are leucocytes which emigrate from the vessels of the sclera and conjunctiva, and make their way to the point of irritation. In part they pass to this through the corneal tissue, either by means of the cell spaces, passing from space to space through the communicating channels, or they take a more direct route between the fibres. When in the cell spaces they retain their round form, when between the fibres they are elongated, but not so much so as in the same place in the normal. This is due to the fact that the tissue is œdematous and the fibres are somewhat separated by the fluid between them. Comparatively few cells reach the centre by this route. Most of those found there come more directly. In the normal fluid of the conjunctiva a few leucocytes will be found, in addition to desquamated epithelial cells. If the fluid be examined a few minutes after inoculating the centre of the cornea with a pure culture of the staphylococcus aureus great numbers of leucocytes are found. These pass not into the corneal tissue after emigration, but directly through the conjunctival membrane into the sac, and from here into the wound made in the centre. They are attracted to the centre by the mysterious quality termed chemotaxis, the attraction being exercised by the exciting agent, by the necrotic tissue, or both.

The number of leucocytes and their situation in the tissue vary enormously in the different sorts of inflammation. They are most numerous in the acute inflammation produced by inoculation with the staphylococcus. Their presence in the central lesion is facilitated by an opening in the tissue by means of which they can enter. It is possible by various means to produce a limited necrosis of the tissue without any

lesion of continuity, and in these cases the infiltration around the lesion may be entirely absent. Leucocytes will, however, always be found in varying numbers around the periphery.

The corneal corpuscles take no part in the production of these cells. They proliferate, but the resulting cells are new corneal corpuscles which take the place of those which have been destroyed. In exciting an inflammation in the tissue the corneal corpuscles immediately acted on are destroyed, and the proliferating cells are confined to the small area surrounding the corpuscles thus destroyed.

My experiments' on the cornea have been made mainly with the view of determining more closely the various steps in the process, and the part played by the different leucocytes found in the blood.

Rabbits were used almost exclusively for the experiments, and the eye inflamed after a local anæsthesia was produced by cocaine, or general anæsthesia by ether. With few exceptions a more intense inflammation followed a lesion of the same character when cocaine was used. For producing inflammation a pure culture of a virulent staphylococcus was used, the inoculation being made by scratching the centre of the cornea with a knife on the point of which a small amount of the pure culture was placed. The animal was killed and the eyes examined after intervals of 6, 8, 12, 18, 24, 36, and 48 hours, and daily up to the 13th day.

For studying the aseptic inflammations nitrate of silver, caustic potash, and chloride of zinc were used as irritants, and the eyes examined after varying intervals. Usually there is difficulty in confining the lesion produced by caustic potash to a small extent of service, but this was overcome by the use of a fine glass tube filled loosely with absorbent cotton, which was cut off flush with the end of the tube. The cotton was moistened with a saturated solution of the caustic, and the end of the tube placed in contact with the surface.

The tissue was examined in the fresh state after staining with nitrate of silver, or after hardening in Zenker's fluid or corrosive sublimate alone. For the silver method the animal is anæsthetized and the cornea thoroughly rubbed with a

crystal of the silver, an attempt being made in this way to re-
move the surface epithelium.   The animal is kept anæsthet-
ized for ten minutes, after which it is killed.   The cornea at
once takes on a dull grayish appearance, and a whitish pre-
cipitate appears in the anterior chamber.   The eye is then
enucleated and washed for ten minutes in running water,
after which the cornea, with a part of the scleral margin, is
removed and exposed to the action of diffuse daylight, in a
mixture of glycerine and water to which a couple of drops of
acetic acid have been added.   In twenty-four hours the tissue
has become brown and is slightly swollen.   Four incisions in
the shape of a maltese cross, extending from the periphery
almost to the centre, are made in it, and it is cut into thin
sections by the freezing microtome.   ·There is no difficulty in
making twenty to thirty sections, taking in the entire extent
of the cornea.   The excellence of the sections depends upon
the sharpness of the knife and the proper degree of hardness
produced in freezing.

The sections are washed in water until all trace of the acid
has disappeared, stained in hæmatoxylin, and mounted in
balsam.   The mounting should be done entirely on the slide.
The sections are removed from the water, spread out on the
slide, and treated with eighty per cent. alcohol, aniline oil,
xylol, and balsam, the sections being blotted between the use
of each reagent.

In many cases one eye was treated with silver and the
other hardened and cut after embedding in paraffine.   Both
of these methods of preparation are necessary for the study
of all the steps of the process.   Each has certain advantages
over the other.   The situation of the leucocytes in the tissue
is best seen in the silver preparations.   The nuclear figures
in the dividing corpuscles are also preserved in a remarkable
manner in this way.   The form and character of the leuco-
cytes is best shown after hardening in Zenker's fluid or subli-
mate.   It would carry us too much into detail to attempt a
description of the various stages of the inflammations so pro-
duced, and I shall only attempt to give you the general feat-
ures of the process.   This will include —

1 st.   The character of the leucocytes which emigrate.

2 d.   From what vessels do they come.

3 d.   What changes do they undergo in the course of their
          migration.

4th.   What changes take place in the corneal corpuscles.

5 th.   Under what conditions, and how, does the new for-
          mation of blood-vessels take place.

From a study of the rabbit's blood and of inflammation in
various parts of the body produced in various ways we can
conclude that there are three distinct varieties of leucocytes
which emigrate and take part in the inflammatory process:
First, the leucocytes, which I shall speak of as the granular
leucocytes, and which correspond to the polymorphonuclear
leucocytes in human blood.   These leucocytes have a nucleus
composed of several more or less irregular fragments which
are all united by slight filaments of nuclear material.   The
nucleus stains intensely with all sorts of staining reagents,
having about the same degree of affinity for color as has the
chromatin of a nuclear figure.   The nucleus is homogeneous,
and no structure can be distinguished in it.   The protoplasm
is granular, the granules round, of equal size, and they stain
intensely with eosin.   Around the cell there is a perfectly dis-
tinct, dense, limiting membrane which is brought out sharply
in corneas stained with Mallory's phosphotungstic acid hæma-
toxylin.   This limiting membrane is one of the most distinct
features of the cell, and is more marked in these cells than in
any others in the body.

The second variety I shall designate as the non-granular
leucocytes.   These are about the same size as the first named.
The nucleus is usually elongated and curved in various de-
grees.   Often it has the definite form of a horse-shoe.   It is
never divided into small masses as is the first named.   It does
not stain so intensely, and is more or less granular.   The
periphery is colored more intensely than the centre.   The
protoplasm is slightly granular, but the granules have no
definite size and no special staining affinity.   There is no cell
membrane giving a sharp outline to the cell as in the granular
leucocytes.

The third variety is the lymphocyte.   This is much smaller than the first two, and has a perfectly characteristic nucleus. The nucleus is round, the periphery stains sharply, and small masses of chromatin project from the periphery and are connected by chromatin threads with similar granules in the interior, giving the nucleus a granular, reticular appearance, even under low power.   There is no cell membrane, and only a very small rim of homogeneous protoplasm can be distinguished around the nucleus.   Often even this small amount seems to be absent.

All these leucocytes emigrate.   The numbers of each found in the tissue vary with the character of the inflammation, its intensity, and the time which has elapsed since the infliction of the injury.   The granular leucocyte is by far the most active in the emigration.   It is found in greatest numbers, it is the first to emigrate, and in the early stages of inflammation it may be found alone.   In the normal cornea this leucocyte is the only one found in the tissue.   It is found also in the tissue of the normal mesentery, and seems to be the only form of wandering leucocyte in normal tissues. Fifteen minutes after inoculating the centre of the cornea with the staphylococcus these cells are found in considerable numbers in the tissue of the conjunctiva.   They pass from the vessels by means of their amœboid motion and at once begin their process towards the centre.   In passing through the corneal tissue they seem to travel by preference between the fibres.   Their motion, as far as can be judged by the examination of the specimens which have been instantly set by the hardening fluid, is similar to that of an amœba. · They become easily broken up and destroyed.   Observing a cornea containing a number of them, one is struck by the presence of small round masses in their vicinity.   These masses are of various sizes, and contain a varying number of granules similar to those in the cell.   Occasionally a corpuscle between the fibres seems to leave behind a trail of these small fragments — occasionally the entire cell fragments.   Both nucleus and protoplasm break up into a number of smaller and larger fragments.   Between the fibres, even when drawn out into

a long filament, which is sometimes so long as to stretch across the field of an immersion lens, the particles of the nucleus are not separated, but remain connected by a filament, often so thin as to be visible only under an immersion.

In the process of migration the nucleus is always directed towards the objective point, and in migrating from a vessel the nucleus with a small mass of protoplasm passes through first. These cells in part pass through the cornea; in part they take a much more direct route to the centre by means of the conjunctival sac. Even in the cornea they are found in much greater numbers in the upper layers and are constantly passing from here to the surface through the epithelium. In the early stages of inflammation all the leucocytes found around the centre are composed of this variety. In the centre they are so closely packed that their situation is obscured, but on the edge of the mass it is evident that they are between the fibres. They undergo such rapid fragmentation here that in places only a granular mass of cell and nuclear fragments can be made out.

The second variety, the non-granular leucocytes, vary extremely in number. They are most numerous in corneas examined 18–24 hours after inoculation. In the tissue they are most frequently found in the cell spaces, though not confined to this situation. It is always easy to distinguish them from the others. Between the fibres they are usually pointed at both ends, the nucleus being in the middle. They are numerous in the cell spaces in the periphery; they do not seem to pass into the conjunctival sac to any considerable distance, and I have not found them in the central lesion. Their motion is slow; they are not found in the irregular forms with knob-like prolongations which are characteristic in the first.

The third form of wandering cell found in the tissue is the lymphocyte. Probably only a small part of these come from the vessels, and their emigration is rarely seen. They do not appear in the corneal tissue before the fourth day, and then are usually found only in the cell spaces around the periphery. I have never found them between the fibres. It is

probable that they have some feeble power of amœboid
motion, for they have been seen in the act of passing through
the wall of a vessel, and are also found in shapes strongly
suggestive of this. When the tissue is being vascularized
they are frequently seen in the vicinity of the newly-formed
vessels. Their presence in the cornea is only partly to be
accounted for by active emigration. Probably the most
potent factor in bringing them there is the increased lymph
stream entering the tissue, they being carried along in this
just as are the red corpuscles. Red blood corpuscles are
found in considerable numbers in the periphery of the cornea
48 hours after an intense inflammation has been produced by
the staphylococcus inoculation. Most of the lymphocytes
come from the mass of lymphatic tissue found around the
vessels outside of the cornea. The normal tissue here con-
tains great numbers of these cells, and the inflamed tissue is
so packed with them as to suggest a section of a lymphatic
gland. They are added to slightly by emigration, the in-
crease being principally due to multiplication of the existing
cells. Evidence of this multiplication is found in the presence
of numerous clear figures. The division of the cells always
takes place by mitosis, and not, as has been assumed by some,
by direct division.

In studying sections of corneas five days or more after
central injury, cells are found which do not correspond with
any of those mentioned, and it was only after studying inflam-
mation in other tissues that their character became plain.
They are only found in the outer third of the cornea, never
around the central injury. They are both in the cell spaces
and in the tissue between the fibres. These cells are as large
as the granular leucocytes; the nucleus is round or oval, with
the characteristics of the lymphoid nucleus; the protoplasm
is dense, non-granular, and stains deeply. Similar cells are
found in the tissue of the conjunctiva, and among the lym-
phoid cells around the vessels.

The study of inflammation in various tissues has enabled me
to recognize these as plasma cells. They are formed from
the lymphoid cells by the gradual formation of protoplasm

around the nucleus.   They are more actively amœboid than are the lymphocytes, as their presence between the corneal fibres shows, but they are never so active as the granular leucocytes.   Cells showing every gradation between lymphoid and plasma cells are found in the surrounding tissue, and occasionally in the cornea.   The conversion of lymphoid cells into plasma cells probably takes place in the outside tissue from which they enter the cornea.

The lymphoid cells' and their derivatives are the only migrating cells which show any progressive changes.   The other leucocytes simply degenerate.   I have never found any nuclear figures or other evidences of cell division in them.

In making flat sections of the cornea which include the surrounding conjunctiva and sclera, two sets of vessels will be found.   Immediately beneath the conjunctival epithelium and in the loose connective tissue there are numerous fine capillaries.   Lower down and immediately outside of the cornea there is a plexus of large veins.   These veins are almost cavernous, and have frequent communications with one another.   They are surrounded by lymphoid tissue.   It is from these vessels that the emigration of leucocytes takes place.   One often finds great numbers of leucocytes in the conjunctiva and surrounding the vessels in it, while in the vessels themselves, apparently, a normal circulation is going on.   I regard this plexus of vessels around the cornea as principally serving its nutrition, and from them both the emigration and new formation of blood-vessels take place.

Changes in the corneal corpuscles are both regressive and progressive, and in no tissue can such changes in cells be studied to such advantage as in the cornea.   In producing inflammation of any form the corneal cells which are acted upon by the irritant are destroyed.   When nitrate of silver is used to produce the injury the tissue immediately acted upon is coagulated and destroyed.   The silver is precipitated in the ground substance and a dark brown eschar is produced in which the outlines of the cell spaces are distinct.   Immediately around the periphery of the eschar the cell spaces are small and contracted, and on staining the tissue with hæma-

toxylin an irregular, contracted nucleus, or often fragments of the nucleus, is seen in the space. Farther out in the tissue another form of degeneration is seen. The protoplasm of the cell is broken up into a great number of larger and smaller fragments which are marked off by silver lines between them. The chromatin of the nucleus separates out and forms a number of small crescentic shaped or round masses which are arranged both around the periphery and within the nucleus, the remainder being perfectly clear. The form of the nucleus changes, it becomes large, more irregular in shape, and a central depression appears on each side. The masses of chromatin separate and become arranged in about equal amount in two circles. The constriction increases, the nucleus becomes divided, and two or in some cases three or four such degenerated nuclei are found in a single fragmented cell. This is the direct nuclear division. That it is a regressive and not a progressive change is shown by the fact that no new cell is produced and in the same preparations changes from this to complete fragmentation of both protoplasm and nucleus are formed. These peculiar forms of degeneration seem to be more marked in those corneas in which cocaine was used as a local anæsthetic.

In the eyes in which inflammation was produced by inoculation with staphylococcus aureus the number of leucocytes in the upper layers of the cornea around the centre is so great that the regressive changes in the corneal corpuscles are obscured. Lower down we reach an area where neither the leucocytes nor bacteria have penetrated, and in this the cell spaces are irregular and shrunken, and the nuclei of the corneal corpuscles small and angular. This necrotic area, which is always of small extent, is bordered by normal corpuscles, in which, however, there is no sign of activity. Progressive changes in the corneal corpuscles leading to the formation of new corpuscles to take the place of those which have been destroyed are most active in the vicinity of the lesions produced by caustics. The activity of this process varies, and seems to depend upon a number of conditions. It is most marked in young animals, and in those cases in

which no break was made in the tissue by the application of the caustic. These changes in some cases begin twelve hours after the injury, and twenty-four hours afterwards there are numerous nuclear figures in the tissue. The first change seen in the corpuscles preceding division is in the protoplasm. In staining the normal cornea with the ordinary nuclear stains, only the nucleus is colored, and that slightly.   In the regenerating cells the protoplasm becomes more abundant, · .slightly granular, and the whole mass stains. The nucleus changes its character.   It becomes round or oval, more granular, and stains more deeply.   The ordinary process of nuclear division then takes place.   While this is going on the protoplasm increases still more in amount, and long protoplasmic branches are given off which extend up into the necrotic area.   All the processes of the cells extend in this direction only.   No processes are given off in the opposite direction.   At first the protoplasmic branches are devoid of nuclei, afterwards the young nuclei make their way into the branches and active nuclear division takes place in them.

The cell growth is not homogeneous, affecting all parts of the circle, but seems to be especially marked in certain places in groups of corpuscles.   In these places the ground substance is reduced to very small amounts, the whole area being taken up by the growing cells.   In general the growing branches are long and pointed.   In places they become broader, the protoplasm increases, processes are given off, and a new typical corpuscle is formed in the course of such a branch.   The length of some of the processes is remarkable. I have frequently seen them so long that they pass beyond the field of a four mm. objective.   They always extend in the same plane and between the fibres; none seem to penetrate the over and underlying planes.   Four days after cauterization with caustic potash the central eschar is filled with these branches and with new corpuscles formed from them.

In these growing cells a great variety of forms of cell inclusions will be found.   Most of the included cells are of

leucocytic origin, though the necrotic corneal corpuscles form some part of them. They are found both in the main body of the growing cells and in the processes. Most of them are not in close contact with the protoplasm, but are surrounded by a clear space which probably represents a digestive vacuole. Unchanged leucocytes, with the silver outline around them, may be found alongside of the cells, and every transition between these cells and mere fragments of protoplasm may be seen. The first change in the included cells is in the nucleus, which becomes separated into fragments. These may be retained in the cell, or fragmentation of the protoplasm may take place at the same time, often a small portion of protoplasm being left around the nuclear fragments, and these may be included in different parts of the growing cell. The cell inclusions formed in this way are of special interest in view of the importance which has been assigned to these particles when they are found in the growing cells of tumors. It seems perfectly evident that the leucocytes serve here as food for the growing cells; that they are not necessary is shown by the fact that equally active processes of regeneration are found in cases in which there are no leucocytes. The regenerative processes are usually limited to the row of corneal corpuscles immediately adjoining the necrotic area. Only occasionally are regenerative changes found in the corpuscles farther towards the periphery.

We have already alluded to the partial and complete fragmentation of the granular leucocytes when passing through the tissue. These fragments are also taken up by the corneal corpuscles in their vicinity. Most frequently they lie close to the nucleus, which may be deeply indented, and in sections made across the indentation they seem to be completely enclosed in the nucleus. Each fragment is surrounded by a clear space in the protoplasm. They frequently contain the brightly stained eosin granules of the cells from which they are derived. They may also be found in the nongranular leucocytes, and in these the brightly stained masses of eosin granules make a sharp contrast with the non-

granular protoplasm.   They do not seem ever to be included
in cells of the same character as those from which they are
derived.

    A new formation of blood-vessels in the cornea is always
seen when the central inflammation is intense, or when a
large area of necrosis has been produced.   It seems to be
intimately connected with the processes of regeneration,
though when the area of necrosis is small, complete regen-
eration may take place without any vascularity.   It is most
pronounced in the intense inflammations produced by aureus
inoculation.   The new formation of blood-vessels takes place
around the entire circumference of the cornea in case the
inflammation is exactly central, or from the nearest point of
the margin in case the inflammation is not central.   The
growth of vessels seems to be more active in the region of
the insertion of the ocular muscles than elsewhere.   The
first evidence of new formation of vessels is seen forty-eight
hours after injury, in an active proliferation of the cells of
the large veins, from which the emigration has taken place.
The tissue here is filled with leucocytes and lymphoid cells,
and, among these, large protoplasmic outgrowths from the
vascular cells appear.

    It has been impossible, in my specimens, to follow the exact
details of the beginning formation.   A short while later,
masses of cells, always preceded by a pointed cell, grow up
into the corneal tissue.   Red blood corpuscles appear be-
tween and around these cells, and finally a space is seen
among them which is filled with red corpuscles and leucocy-
tes.   This mode of formation corresponds with that ordi-
narily described.   In other cases the process seems different.
Large numbers of red corpuscles appear in the cell spaces
immediately around the vessels, and these seem to become
surrounded by the growing cells, and in this way converted
into vessels.   In one specimen it was possible to show a
growing vessel opening into a cell space which was filled with
red blood corpuscles and which extended from this for a
short distance between the fibres.   The corneal corpuscles
do not appear to take any part in this new formation of ves-

sels. They remain unchanged in the vicinity of the growing vessels. The vessels supplying the conjunctiva show no changes. The new vessels are formed exclusively from the plexus of veins around the edge, which should be regarded as the essential vessels of the cornea.

It is not the purpose of this paper to describe the abscess formation and ulceration produced in the cornea by inoculation with the S. P. Aureus. My purpose has been mainly to show the different sorts of leucocytes which enter the tissue and the part they severally play in the inflammatory process. What we have seen take place in the cornea is applicable to the various forms of inflammation which may be produced in other tissues of the rabbit. In studying inflammatory processes in man it has not been possible for me to separate so clearly the different forms of leucocytes from one another, for the distinctions do not appear to be so marked in man as they are in the rabbit. We are dependent entirely on chance for our material, and the conditions of the inflammation are to a great extent unknown. Any one who has studied the character of the cells in the exudation in a number of cases of acute croupous pneumonia must have been struck with the great differences in the character of the cells in the alveoli. A comparative study of these cells and the conditions under which they appear is being undertaken in the pathological laboratory of the Harvard Medical School.

DESCRIPTION OF PLATES.

PLATE I.

FIG. 1. — That section of cornea stained with nitrate of silver, showing a nerve and cell spaces in the tissue. 16 mm. obj., 4 comp. ocular.

FIG. 2. — Section of slightly œdematous cornea, showing silver lines between corneal fibres. 16 mm. obj., 4 proj. ocular.

PLATE II.

FIG. 1. — Section of normal cornea, showing cell spaces with granular leucocyte between the fibres. Observe in the leucocytes the filamentous thread of muscular substance between the larger portions of nucleus. Nitrate of silver and hæmatoxylin. 8 mm. obj., 4 proj. oc.

FIG. 2. — Section of normal cornea showing granular leucocyte in cell space. Nitrate of silver and hæmatoxylin. 8 mm. obj., 4 proj. ocular.

FIG. 3. — Section of cornea 48 hours after central inflammation induced by nitrate of silver, showing leucocytic infiltration between the fibres. Nitrate of silver and hæmatoxylin. 16 mm. obj., 4 proj. ocular.

PLATE III.

FIG. 1. — Flat section of centre of cornea 18 hours after inoculation with staphylococcus aureus. The corneal corpuscles are destroyed, and there is infiltration with granular leucocytes in cell spaces and between fibres. Nitrate of silver and hæmatoxylin. 8 mm. obj., 4 comp. ocular.

FIGS. 2, 3, 4, 5, 6, 7. — Section of cornea 24 hours after staphylococcus inoculation, showing granular leucocytes in tissue. At the lower end of the leucocytes shown in Fig. 4 a small portion of the protoplasm is being thrown off. Observe particularly the outlines of the cells. Stained in phosphotungstate hæmatoxylin. 2, 5, 6, 7, 2 mm., obj. 8 comp. ocular. 3 and 4 same obj., 4 comp. ocular.

FIG. 8. — Granular leucocytes in tissue. Eosin and methylene blue. The granules in the cells are so fine as to be nearly invisible. Compare the granules here with the granules in the other cells stained with phosphotungstate hæmatoxylin. 2 mm. obj., 4 proj. ocular.

FIG. 9. — Non-granular leucocytes in cell space with corneal corpuscle. Observe in these the absence of the sharply stained cell membrane. Phosphotungstate hæmatoxylin. 2 mm. obj., 4 proj. ocular.

PLATE IV.

FIG. I. — Corneal corpuscle with fragments of granular leucocytes adjoin-
          ing nucleus. There is also a non-granular leucocyte, proba-
          bly in same cell space. Phosphotungstate hæmatoxylin. 2
          mm. obj., 4 comp. ocular.

FIGS. 2, 3, 4. — Degenerative fragmentation of corneal corpuscle with
          direct division of nucleus. 2 mm. obj., 8 comp. ocular.

FIG. 5. — Group of proliferating corneal corpuscles adjoining central
          lesion. Nitrate of silver and hæmatoxylin.   4 mm. obj., 4
          proj. ocular.

FIGS. 6 and 7. — Nuclear division in corneal corpuscle adjoining central
          lesion. Nitrate of silver and hæmatoxylin.   2 mm. obj., 4
          proj. ocular.

FIG. 8. — Formation of blood-vessel. A cell space filled with red blood
          corpuscles which have penetrated between the fibres beyond
          this. In the lower portion this space communicates directly
          with a blood-vessel. The growing endothelium of this is
          advancing over the space. 2 mm. obj., 4 proj. ocular.
          (All the lenses used were of Zeiss make.)

Fig. 1.
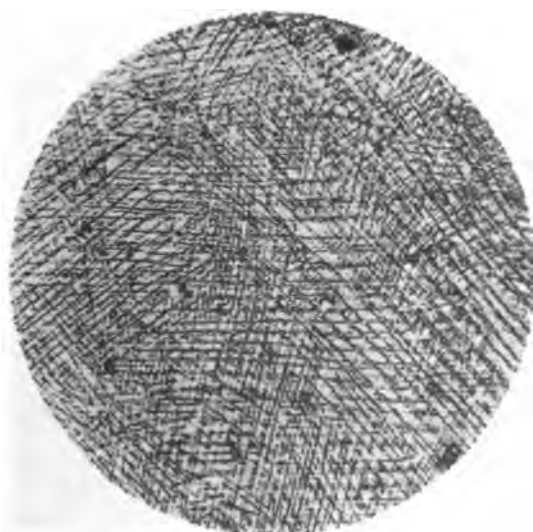
Fig. 2.

Fig. 1.

Fig. 2
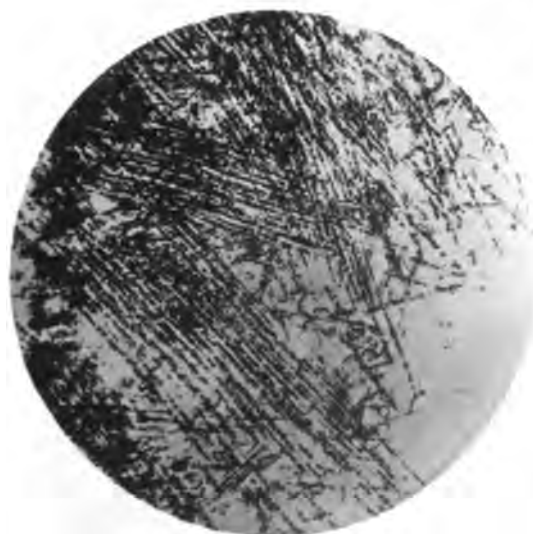
Fig. 3

Fig. 2.

Fig. 9.

Fig. 4.

Fig. 1.

Fig. 8.

Fig. 3.

Fig. 5.

Fig. 6.

Fig. 7.

COUNCILMAN — KERATITIS

Fig. 1.

Fig. 2.

Fig. 3.

COUNCILMAN — KERATITIS.
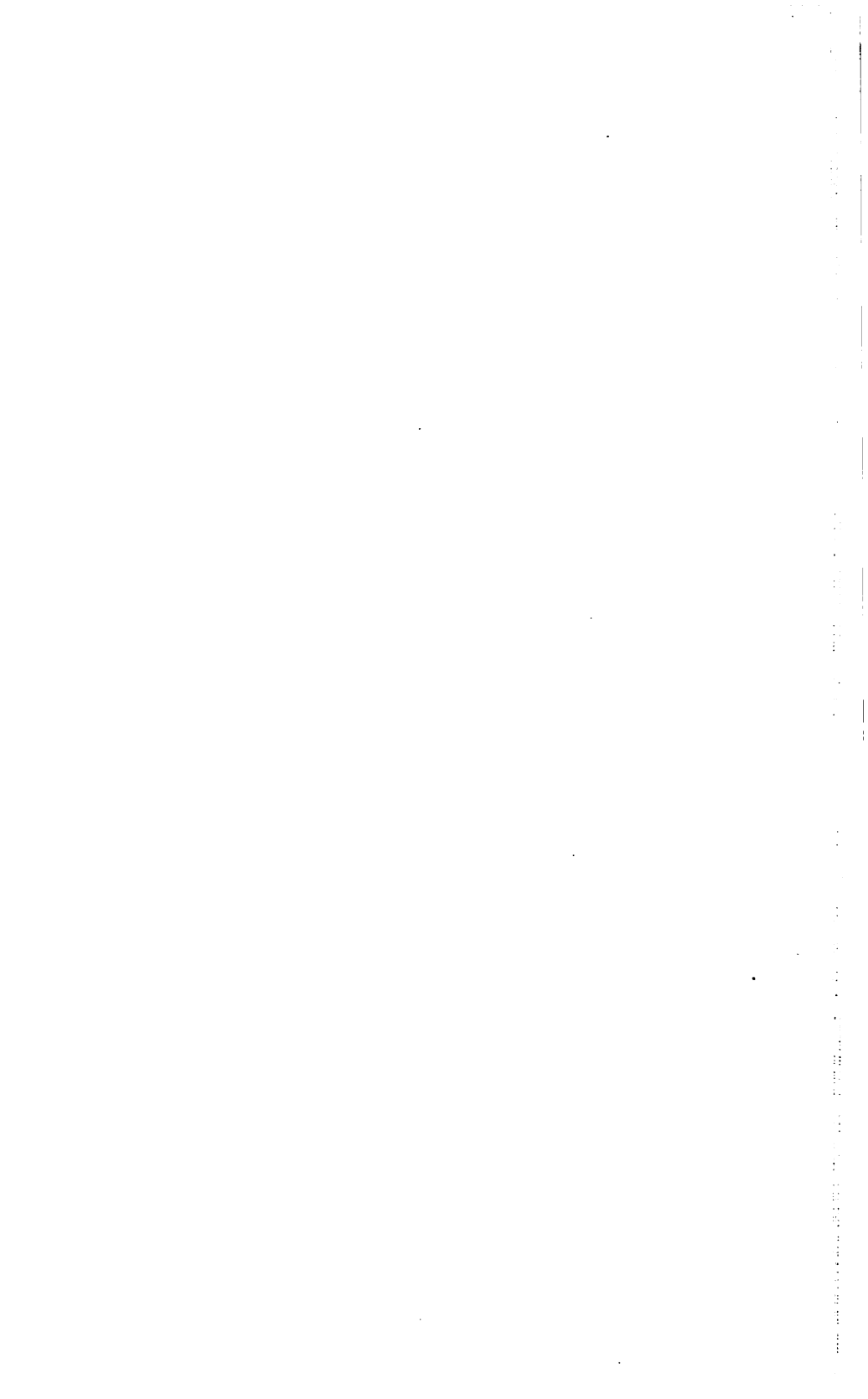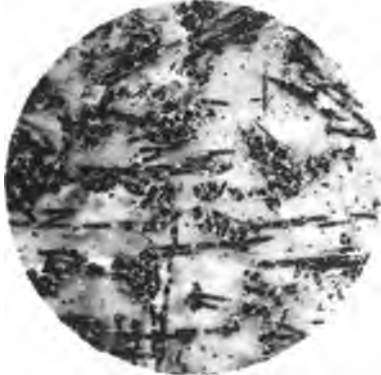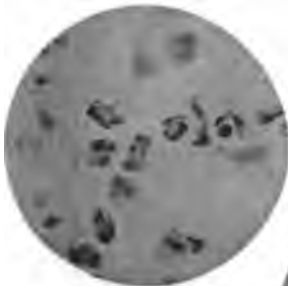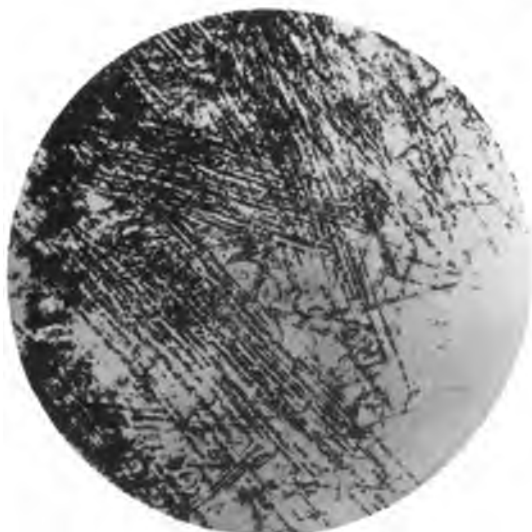
OBSERVATIONS ON THE EFFECTS PRODUCED BY THE 6–MM.
RIFLE AND PROJECTILE. — AN EXPERIMENTAL STUDY.

By HENRY G. BEYER.

The experiments which will be found described in the
pages that follow were made in the harbor of Port Royal,
S.C., where the United States Steamship " Amphitrite " was
engaged in the training of gun captains, during the four
months immediately preceding the outbreak of hostilities
between this country and Spain.

The navy having recently been equipped with a new small-
arm of special description, with a projectile of certain defi-
nite dimensions and a composition marking it out as differing
from other projectiles, it had become necessary to determine
its effects upon animal tissues and organs by the usual ex-
periments made with this end in view.

The United States Navy Rifle, ·M. 1895, is known as the
" Lee Straight Pull Rifle," [1] and is a rapid-fire and repeating
arm rather than a magazine gun.   It may be used as a single
loader, if the magazine be not charged, but in general it
will be used as a repeater, five cartridges in a clip being
entered in the magazine, and the gun not being reloaded
until this charge is exhausted.   In case loose ammunition is
furnished, the magazine may be charged with single car-
tridges, any number from one to five being entered.

The original bullet was made of hardened lead (95 %
lead and 5 % antimony), with a jacket of a material known
as cupro-nickeled steel.   It was steel plated with an alloy of
copper and nickel.   The weight of the bullet was 135 grains.
In March, 1897, a change was made in the bullet, bringing
the weight down to 112 grains, substituting a copper jacket,
tinned, in place of the steel jacket, covered with an alloy of
copper and nickel, thus raising the velocity from 2,460 to
2,560 feet per second, thereby, however, also increasing its
liability to deformity.

All authorities are agreed that one of the most important

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[1] Alger and Twining.

qualities tending to increase the penetrative power of a modern small-arm projectile is the hardness of its mantle or jacket. Whenever we depart from a hard-steel jacket and substitute for it the softer copper jacket, for example, the penetrative effect of our projectile must be proportionately decreased, while its explosive effect must be correspondingly increased.

On the other hand, according to Kocher, all those qualities in a projectile which are calculated to increase its penetrative power tend also to decrease its explosive effects;[1] and, according to the experiments made by Bruns, the hydraulic pressure, although increased, as a rule, with increasing velocities, has not increased with the velocities in the same proportions, on account of the reduction in the calibre of the projectiles. This is held by Kocher to be true for the explosive effect in general.

Shots fired at Inanimate Material.

1. Jan. 6, 1898. Lead plate (see fig. 5, pl. I. and II.), 3 cm. thick, 8 cm. on a side, weight 2.25 kilos, suspended by rope-yarn from the upper cross-piece of a wooden frame, at a distance of 5 feet from the muzzle of the gun; white sheet of paper hung in front and rear of the plate; velocity of bullet 2,560 feet p. s.; entrance opening 24 mm. in diam., exit 36 mm. in diam.; channel funnel-shaped or conical. Front crown 6 mm. high, rear crown from 6 to 12 mm. Paper in front and rear sprinkled over with lead-colored spots, and perforated with numerous small and large very irregular holes. Small strips from the copper jacket may be seen lining the inside of the channel in the plate; some larger strips of copper, also, found in the oakum bag used for catching the bullets, and placed directly in the rear of the lead plate. Small particles of lead were found on the floor. Loss in weight of plate was 16 grms.

2. s. d. Lead plate (see fig. 6, pl. I. and II.), same dimen-

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[1] Nach unsern schon 1880 publicirten Nachweisen verringern alle Momente, welche, ceteris paribus, die Durchschlagskraft eines Gesctosses erhöhen, dessen Sprengkraft (*loc. cit.*).

PLATE I.

Rubber

Rubber.

Lead

Lead.

Lead

Lead.

ENTRANCES. (See Text.)

PLATE II.

Rubber. | Rubber.

Lead. | Lead.

Lead. | Lead.
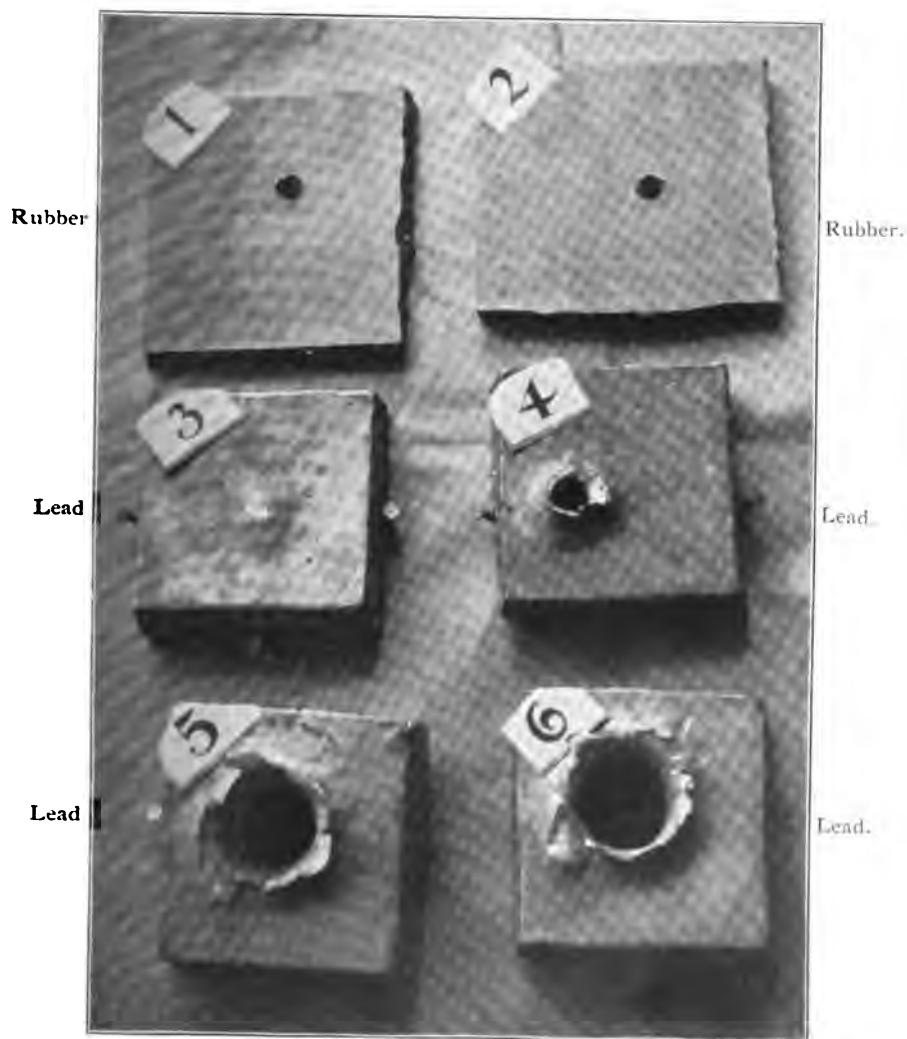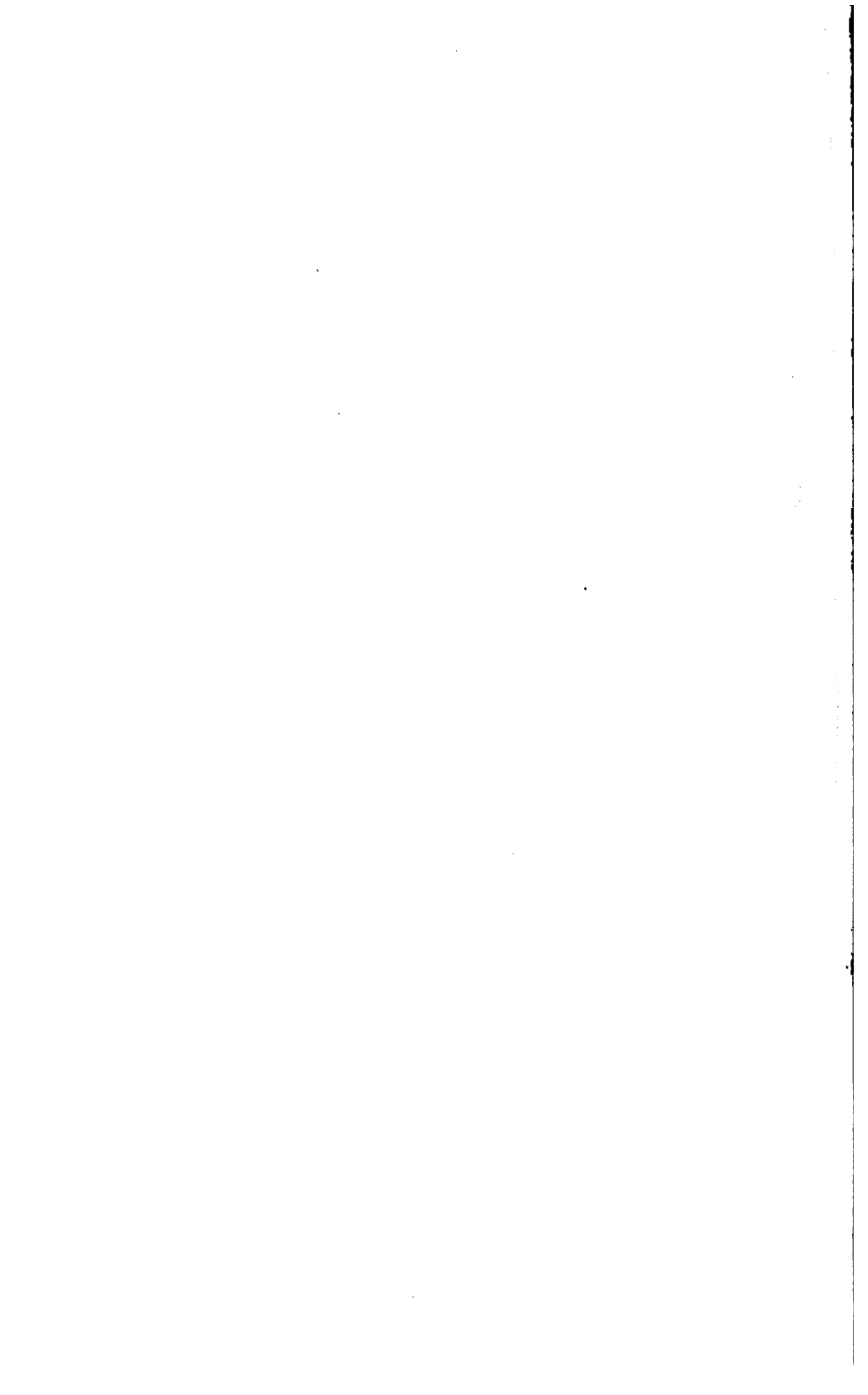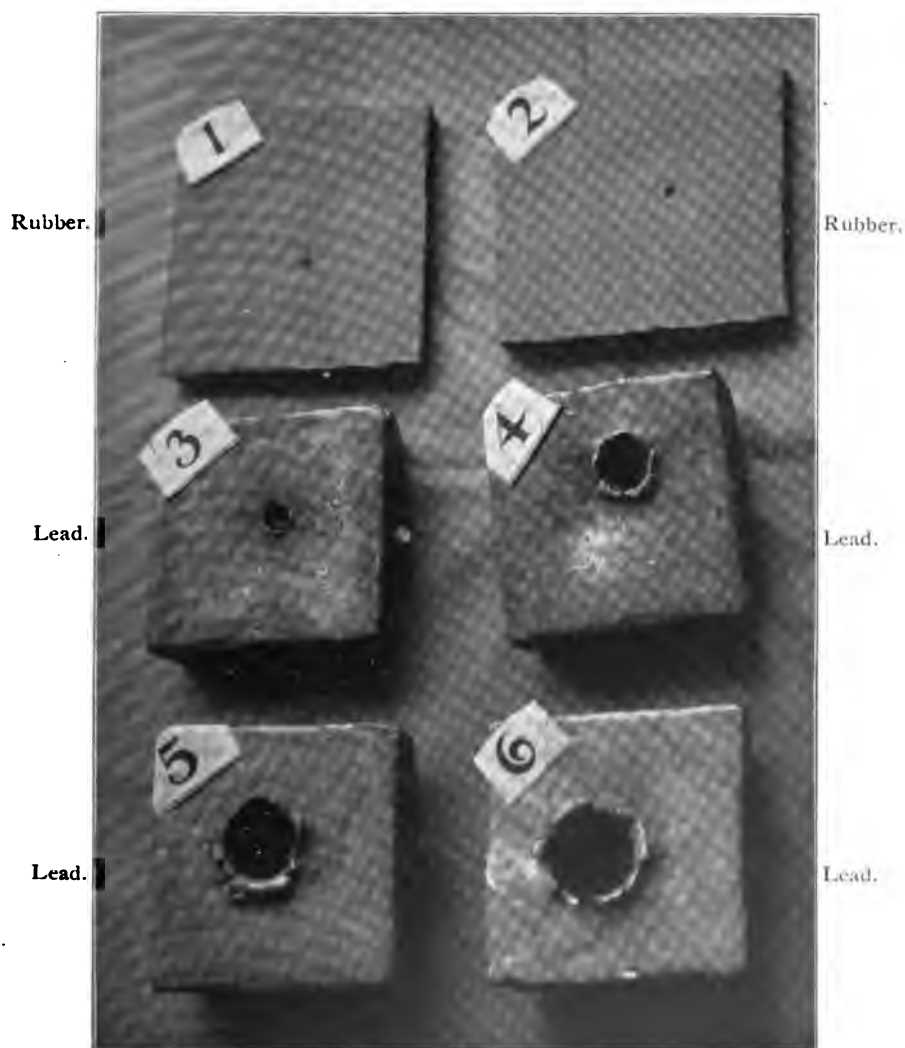
Exits. (See Text.)

sions as preceding, disposed in same manner, and fired at with same velocity. Entrance 26 mm. in diam., exit 40 mm. wide; channel conical and showing small strips of copper jacket lining its walls. Paper in front and rear sprinkled over with grayish spots, and perforated with numerous small and large irregular holes. Bullet went completely to pieces, as in preceding experiment. Loss in weight of plate was 15 grms.

3. Feb. 11, 1898. Lead plate (see fig. 4, pl. I. and II.), same dimensions, and disposed in like manner as preceding ones; muzzle velocity of bullet 1,500 feet p. s., struck plate 5 feet from muzzle; diam. of entrance 20 mm., exit 12 mm. wide, or 8 mm. less than entrance, and bulging to the extent of 6 mm. above the surrounding surface; channel smooth and conical, but the wider portion of the cone is at the entrance. Parts of the copper jacket may be seen lining the channel. Loss in weight of plate was 13. grms.

4. March 5, 1898. Lead plate (see fig. 3, pl. I. and II.), of same dimensions as previous ones. Velocity of bullet 750 feet p. s. Entrance 10 mm. wide; there is no exit. Bullet may be seen lying imbedded in plate; its jacket is empty. The posterior surface of plate, at a point opposite the entrance of the bullet, shows some bulging.

5. Jan. 6, 1898. Plate of fine soft rubber (see fig. 1, pl. I. and II.), 11 mm. thick, 10 cm. on a side, suspended by twine in a wooden frame, 5 feet from the muzzle of the gun, velocity of bullet 2,560 feet p. s. Entrance round, 2 mm. wide; surface of rubber adjacent to opening shows dark discoloration for a distance of 2 mm. Exit 9 mm. wide, irregularly round; channel funnel-shaped or conical and roughened; widest part of funnel is at exit.

6. s. d. Plate of fine soft rubber (see fig. 2, pl. I. and II.) in every respect same as preceding. The same plate shows an opening made by a bullet fired with a velocity of 1,500 feet. The entrance of this opening is 1 mm. wide, being, in fact, a mere point, with a distinct dark ring around it; exit is a mere pin-point, and smaller even than entrance. This is shown in the lower part of the photograph.

7. s. d.   Tin can, 11 cm. high, 8.5 cm. wide (see fig. 8, pl. III. and IV.), empty, suspended by twine, accurately centred, fired at with a velocity of 2,560 feet p. s., 5 feet from the muzzle.   Entrance 7 mm. wide, round, edges inverted.   Exit 6 mm. wide, round, edges everted; tin can scarcely moved and the twine did not break.

8.   Same sized tin can, filled with water (see fig. 9, pl. III. and IV.), suspended and fired at under the same conditions as in No. 7, was blown to pieces, water scattered in all directions; the pieces recovered were all bent out of shape.

9. s. d.   Same sized tin can, filled with marbles (see fig. 13, pl. III. and IV.), fired at with velocity of 2,560 feet p. s., 5 feet from the muzzle.   Entrance 7 mm. wide, and round.   Exit is a large rent, a part of the wall of the can being carried away. The top flew out, the bottom is bulging and presents a triangular hole with everted edges.   Impressions of the marbles are marked all around on the surface of the vessel.   The marbles themselves show the effect of lateral compression, being flattened in certain places.   The bullet went completely to pieces, and particles of lead and of the copper jacket were found in the oakum.

10. s. d.   Same sized tin can, filled likewise with marbles (see fig. 12, pl. III. and IV.), and treated as preceding.   The result was the same, with the exception that two rough irregular holes are to be seen a little to the right of the entrance, through which some marbles were pressed, making their way out of the vessel against the very direction whence the bullet came.   The bullet was completely destroyed, small strips of the copper jacket and lead granules recovered among the marbles, which latter were partly ground into coarse powder and had partly fallen to the floor.   Some of the marbles were also found in the oakum bag.

11.   Feb. 11, 1898.   Empty tin can (see fig. 11, pl. III. and IV.), fired at with a velocity of 1,500 feet p. s., 5 feet from the muzzle; scarcely moved and string unbroken; entrance 7 mm. wide and round; exit of same dimension and edges everted; bullet slightly compressed and flattened at point.

12. s. d.   Same sized tin can, filled three-fourths full of

water, suspended as before, fired at with a velocity of 1,500 feet, 5 feet from the muzzle (see fig. 10, pl. III. and IV.). Entrance transverse diam. 8 mm., vertical diam. 6 mm., prolonged into two fissures, the upper one of which is 6 mm. long, and the lower one 8 mm. long; edges slightly inverted. Exit irregularly quadrangular, 12 mm. at its widest part and 10 mm. at its narrowest part; edges everted and partly curled on themselves. The top flew off, completely bent on itself from without inward, so that it could not be replaced. The sides and bottom of the vessel are bulging outward. The twine only partly broken.

13. Jan. 18, 1898. Plate of finest chrome steel, 7 mm. in thickness, suspended and without any backing, fired at with full velocity, distance from muzzle 50 yards, twice in succession, producing two clean perforations, round and smooth, measuring 8 and 9 mm. in diam. respectively. The same plate with strong backing, fired at with the same velocity and at the same distance, showed deep impression, but no perforation. Distinct whitish star-shaped lines were seen around the impressions, due to melted particles of lead from bullets, which were not recovered.

14. Jan. 6, 1898. Square glass plate, 6 mm. thick, 15 cm. on a side, encased in a wooden frame, fired at 5 feet from the muzzle with a velocity of 2,560 feet. Large portion of the glass was blown out; the remainder shows circular and radiating cracks which are made very distinct, from their milky white appearance. The lines are filled with finely ground glass.

15. Feb. 11, 1898. Large tin can, completely filled with two kg. of dry plaster of paris. The vessel measured 16 cm. in diam. and 16 cm. from top to bottom, being cylindrical in shape and having a well-fitting cover. It was fired at through the centre, velocity 2,560 feet, 5 feet from the muzzle. Entrance round, 6 mm. in diam., but no exit was found. The top cover was blown off and about 100 grms. of the powder were scattered over the floor. Immediate search made for the bullet resulted in finding it 2 cm. from rear wall, in a flattened condition, with very irregular

outline, intimately mixed with the plaster and so hot that it could not be held with the fingers. The vessel showed no deformity whatever, and was not thrown out of the frame, remaining suspended.

16. A canvas bag, 90 cm. long and 25 cm. in diam., cylindrical in shape, completely filled and packed with ship's oakum, and weighing twenty-two and one-half pounds, was tied lengthwise on the top of a barrel, one end of the cylinder pointing inboard, the other end looking out to seaward. Both ends were covered with sheets of white paper and 5 shots were fired through this cylindrical bag parallel to its long axis, with full velocities and 5 feet from the muzzle. All 5 shots went through, a cloud of fine brown dust following each bullet as it went over the side of the ship. The bullets were seen to drop into the water at an estimated distance from the ship of 300 yards. Both the entrances and the exits were small and slit-like in the paper covers as well as in the canvas, indicating little or no deformity on the part of the bullets. The tracks made by the bullets within the oakum were lined with finely powdered oakum.

The same experiment was repeated two days later, but with oakum packed very tightly with a jack, with practically the same result, except that the bullets dropped into the water at a still greater distance from the ship's side than they did in the case of the bag not so tightly packed.

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Nothing, certainly, can be better calculated to show the superiority of experimentation over mere speculation and scientific guessing than a comparison of the different effects produced by one projectile on the various inanimate substances which have been experimented on. A mere glance at the lead plates and the rubber plates will show the most unexpected differences in the effects produced by the same forces acting on them. Very remarkable is the degree of penetration shown in the several substances used. In plaster of paris, for instance, our projectile penetrates to the extent of only 14 cm., and is found to have become flattened like a

PLATE III.

ENTRANCES. (See Text.)
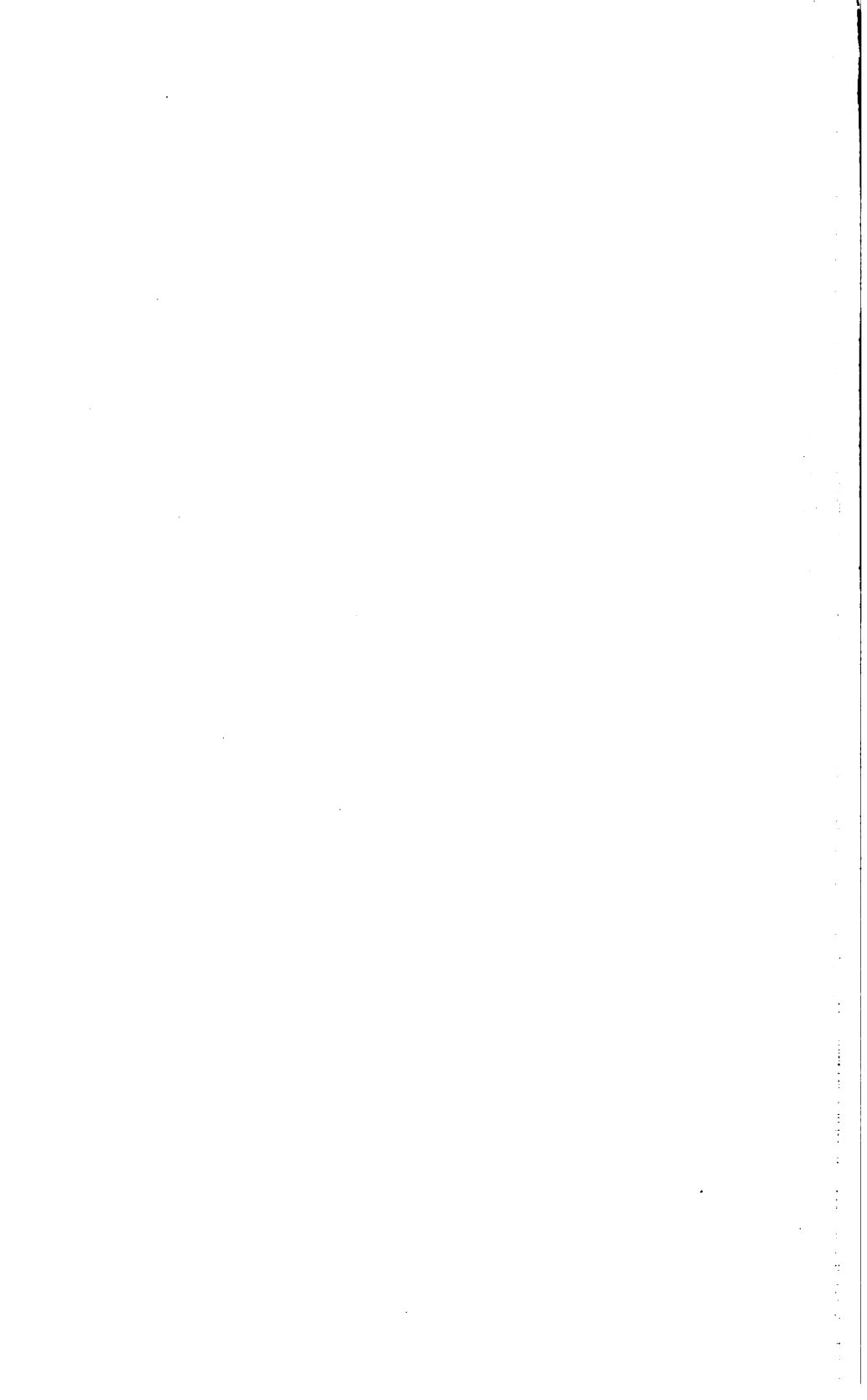
PLATE IV.

EXITS. (See Text.)
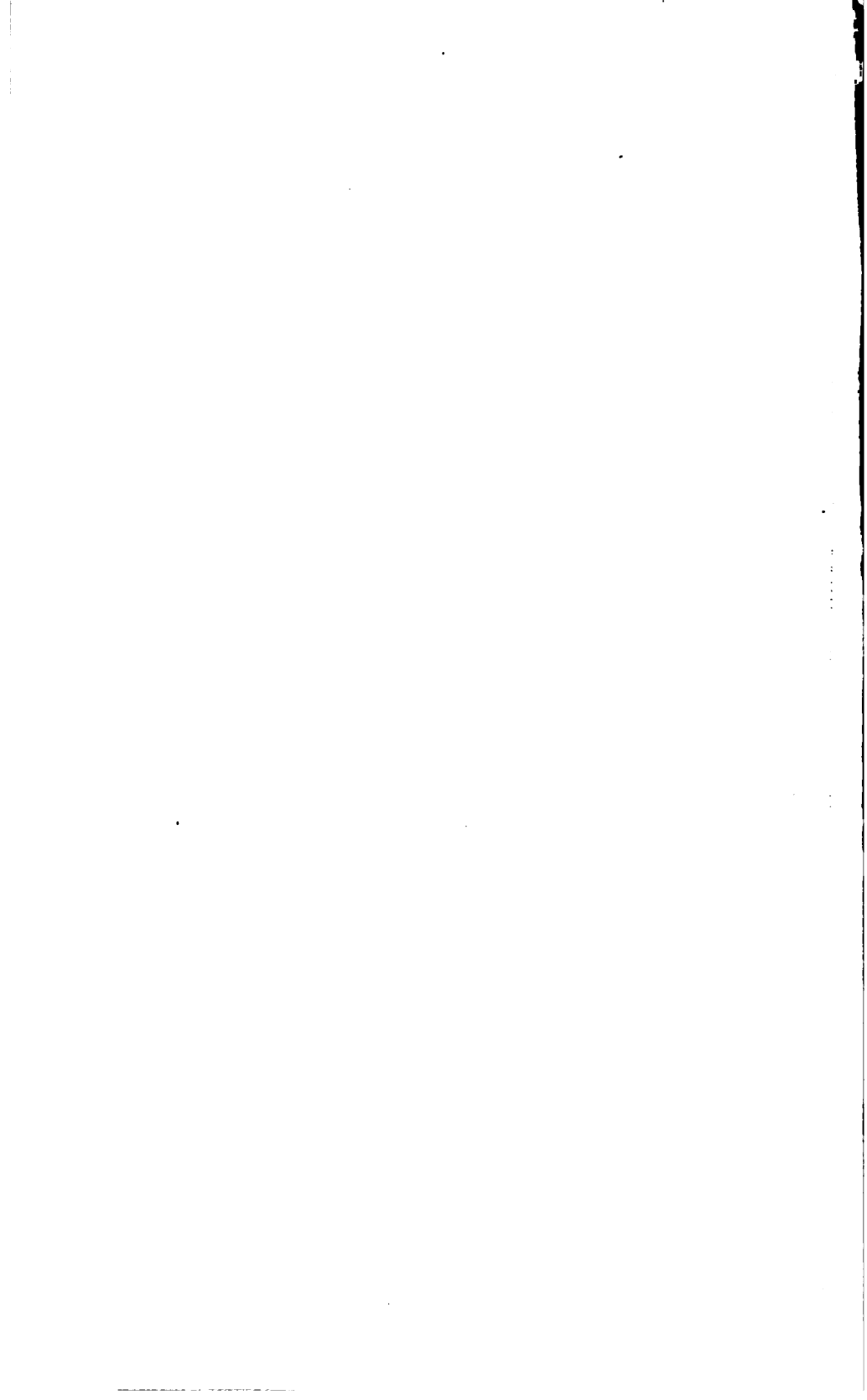
pancake; while in firmly packed oakum its course is not
checked at all, but the bullet passes through the entire length
of the bag, a distance of 90 cm., then goes 300 yards further
before its force becomes exhausted, and comes out without
being deformed.

Figure 12, on plate III. and IV., represents a tin can that
was originally filled with marbles. This tin can shows that a
very high degree of pressure must have been exerted from
some point in its centre in all conceivable directions and at
the moment the bullet entered it. This vessel exhibits and
illustrates what, according to Kocher, is the very highest
degree of explosive effect. We see impressions produced
by the marbles in the tin not only all around the sides of the
vessel, but we notice also two irregular holes in close prox-
imity to the point through which the bullet entered, and
through which two holes several marbles cut their way
through the tin against the very direction whence the bullet
came.

In the lead plate, represented by figure 4, plates I. and
II., in which the entrance is larger than the exit, the explosive
effect was practically exhausted during its passage through
it, while in figure III., shown in the same plates and in which
only an entrance is seen, with some bulging where the exit
ought to be, the power of the bullet was exhausted before
penetration could be completed.

The fact that the decreased penetrative power and the
increased explosive effect exhibited by our projectile may be
attributed to the softness of its mantle or jacket is also proven
by some experiments by Kocher. Kocher experimented
with two projectiles, of which the one had a calibre of 5.8
mm. and a velocity of 810 m.; the other a calibre of 7.5 mm.
and a velocity of 610 m. The former, in spite of its much
greater velocity, produced less explosive effect than the
latter. Both bullets were provided with a hard steel jacket.

The very striking similarity that has been found to exist
between the effects produced by a small-calibre bullet in the
human skin and the lungs on the one hand, and an elastic
rubber plate on the other, must be apparent to every one.

It is, consequently, much more easy to understand that the ordinarily small size of the injuries in these structures is due chiefly to the fact that they contain an abundance of elastic tissue. Moreover, the fact that organs which contain within their meshes a certain fixed quantity of moisture, more or less large, experience injuries that become more serious the greater *cæteris paribus*, this quantity of moisture is, could only be satisfactorily explained on the principles underlying hydraulic and hydrostatic pressures. The further fact that the injuries in bones, especially the harder cortical portions in the diaphyses, are out of all proportion so much more serious than those produced by the same projectiles and moving with identical velocities, on the softer tissues, has become more intelligible by experiments on the more simple substances, such as glass plates, glass tubes, etc.

The most elementary and simple substances had to be interrogated in order to satisfactorily explain the nature of an injury produced in a complex structure.

Of scarcely less importance in this regard has been the study of the physical and chemical composition of the projectile itself. Two bullets, moving with the same velocities, have been found to produce widely differing effects, according to their composition. The tendency of progress in this respect has been marked by a steady, unfaltering advance toward increasing the hardness of the bullet and its mantle. In this direction some improvement seems, however, still to be desirable, since there is scarcely a projectile known which, moving with the enormous velocities at present obtainable, does not suffer deformity on striking hard substances, even at considerable distances from the muzzles of the guns. At present, velocity seems to be far ahead of the durability of the projectile, and, consequently, any change from a hard mantle of a projectile to a softer one must be regarded as a step backward rather than forward, especially so since the gain in velocity through the reduction in weight which is thereby made is practically superfluous.

In view of the facts at present on hand, and considering the very great distance from the muzzle of a modern small-

arm at which a man may still be placed *hors de combat*, we have reached a limit beyond which, according to Kocher, it·would hardly seem to have any sense to go.

When we now examine a little more closely the results obtained with our rifle on some of the inanimate material enumerated above, the first thing which will attract our attention is the difference in the injuries produced by the same projectiles, but moving with different velocities.   In the first four shots, through lead plates, we see these differences .well marked.   The projectiles being the same in all four cases, the differences produced can only be due to the differences in the velocities with which they struck the plates.   In the first three shots the bullets went completely to pieces ; in the fourth a part of the jacket alone remained entire, losing its lead.

The heat produced on impact was evidently great enough to melt the lead of the plate as well as that in the bullet, as is shown by the large number of holes in the paper hung up in front and rear of the plate, and by its grayish discoloration. Since Kocher has shown that particles of lead only separate from a projectile, or other material made of lead, whenever the lead becomes heated up to the melting-point, the above-described appearances on the paper, as well as the fact that small particles of lead were picked up from the floor of the room, must be accepted as sufficient proof of the fact that the lead did melt when the bullets struck the plates.   In addition to this we have the further fact of a loss in weight of the plate, amounting to from 13 to 16 grammes in the different cases.

That hydrostatic pressure is either increased or decreased in direct proportions to increasing or decreasing velocities is well exemplified in our experiments on the tin cans filled with water.   With full velocities the can is simply torn to pieces, while with lower velocities the can not only remains entire, but the exit is not a rent, but simply a quadrangular opening. In both cases, however, the bullets showed considerable deformity.   The full-velocity bullet had lost all its lead, and the jacket was torn and bent upon itself.   The lower-velocity

bullet had also lost its lead, but the jacket showed merely a turning down of its anterior end, the margins of the sleeve being serrated.

The experiments on tin cans filled with marbles would, to my mind at least, illustrate beautifully Kocher's dry pressure theory and its analogy to hydrostatic pressure, as produced in wet or moist substances. In both these instances the effect of lateral pressure is well shown, and there seems to be little or no essential difference in the cans whether they were filled with water or with marbles.

In all the experiments so far made our bullets suffered deformity, from a mere flattening of the anterior end to their complete destruction.

Shots fired through Animal Tissues and Organs.

A. BRAINS AND VISCERA.

Most of the material used in this series of shots was furnished me by butchers who did their own killing, and was obtained in a perfectly fresh, often still warm condition. The dissection and examination of the effects produced by the shots were done on the spot, and the results recorded.

1. Feb. 1, 1898. A small ox was killed by a shot through its head. Bullet velocity was 2,560 feet, distance 10 feet. Bullet entered skull in front, a little above line connecting the upper margins of the two orbits. The animal dropped immediately into the suspension apparatus previously provided for it and made fast above. Entrance opening in skin was 7 mm. in diam., slightly bevelled. Underneath the skin is a loose piece of bone, lozenge shaped; its centre presents a small hole equal in size to that in the skin, but widening towards the inner surface, where it measures 12 mm. This piece of bone is 5 cm. long and 3 cm. broad; removed, it shows the brain to be a shapeless mass, covered with coarse, bony detritus derived from the internal table of the skull.

In this mass of the brain, bony detritus, and blood were found pieces of lead and thin strips from the copper jacket. Several long transverse fissures in the skull were also noticed.

2. March 12, 1898. Calf, seven months old, was shot

through the head; velocity of bullet was 1,484 feet, entering
5 feet from muzzle, animal standing with its left side toward
the gun.   The animal turned half a circle from left to right,
then fell to the ground, but immediately rose again on its feet,
having, apparently, retained complete voluntary control of all
its limbs as well as of the muscles of its neck, trying to run
away from its halter.   A second shot through the neck and
spinal cord a little below the skull felled and killed the ani-
mal instantly.

The first shot entered the skull cavity at a point 1 cm.
behind and below the attached portion of the left ear.   The
entrance opening was 6 mm. in diam.   The exit was found
1 cm. above the bony margin of the orbit and the outer
angle of the right eye.   Both eyes were prominent and
protruding abnormally.   The skin opening at exit did not
exceed the diam. of the bullet, but the finger felt an opening
in the bony skull underneath, somewhat larger than that in the
skin, with a fringe of fine, sharp bony spicules projecting from
the margin toward the centre of the skin opening.   This
shot, then, passed through the calf's head in a direction from
left to right, and from behind forward, the animal turning its
head slightly to the right at the moment of firing.   On re-
moving the calvarium with the small bones attached a clean
perforative opening in the skull was found, without any splin-
tering.   A few very fine short fissures extending through the
dura mater were seen around the opening in the occipital
portion of the skull.   The bullet passed on through upper
portions of the cerebellum on the left side, going directly for-
ward and to the right, passing through the occipital lobe of
the cerebrum, through both ventricles above basal ganglia,
coming out through middle frontal convolution of right half
of the cerebrum, and leaving the skull cavity through a typi-
cal opening in the frontal bone.   The track throughout the
brain was but slightly larger than the diam. of the bullet,
even and smooth, without laceration of any kind, and marked
from one end to the other by a narrow line of bright red
blood, which filled the channel without distending the same.
The rest of the brain had preserved its consistency and form

in a perfectly normal condition.   Although the projectile was not recovered, it could have experienced but little deformity. Ossification in the young skull had not, of course, been completed at that age.

3. Jan. 8, 1898.   The lungs from a pig, freshly killed, inflated and suspended, were fired at with full velocity, 20 feet from the muzzle.   Bullet entered the centre of right middle lobe, making an opening of 15 mm. in diam., a smooth track of the same diam. throughout, and leading to an exit 20 mm. wide.

4. Jan. 22, 1898.   Pig's lungs, freshly killed and inflated, were fired at with a velocity of 1,000 feet p. s., 5 feet from muzzle.   Both entrance and exit smaller than diam. of bullet, so that it is difficult to find either after partial collapse of the lungs.

5. Jan. 22, 1898.   Perfectly fresh cow's liver.   Full-velocity bullet, at 5 feet from the muzzle, passed through centre of flat surface, and caused a rent 19 cm. long, 7 cm. wide, with edges ragged and torn and three fissures 1 cm. deep, and extending 4, 7, and 9 cm. respectively from the margin of the entrance opening.   The exit was 20 cm. long, 9 cm. wide, its edges pulped and everted without fissures. The liver substance was scattered over white sheets of paper, hung up in front and rear.

6. March 5, 1898.   Fresh cow's liver, suspended as usual, with flat surface exposed.   Bullet velocity 1,000 feet p. s., 5 feet from muzzle.   Entrance opening, through centre of liver, of the diam. of the projectile; rear opening 15 mm. long and broad.   The track is slightly funnel shaped, some liver substance is scattered over the paper, and there is one fissure 1 cm. in length and 5 mm. in depth.

7. Jan. 8, 1898.   Pig's kidneys, just removed from the animal, suspended in such a manner that they present their anterior surfaces.   Bullet, with a velocity of 2,560 feet p. s., at 20 feet from muzzle, entered centre of right kidney, and bore away entire medullary portion, including pelvis. The vertical diam. of opening is 5 cm., the transverse diam. 2.5 cm. long.   The capsule shows numerous fissures near

the exit.   Kidney substance pulped for some distance from the opening.   A second shot, fired at the left kidney, almost completely destroyed it.

8. Jan. 22, 1898.   Kidneys from a young bullock, recently killed.   The organs were suspended as usual, with anterior surfaces exposed.   The bullet, with a velocity of 1,000 feet, at a distance from the muzzle of 5 feet, entered: *a*, the centre of the right kidney, causing an entrance opening of 6 mm. and an exit of 7 mm. in diam., the parenchyma in a pulped condition, completely filling the track; *b*, the centre of the left kidney, entrance 6 mm., exit 8 mm., with several small fissures in capsule.   A fine wire pushed through the track produces a small quantity of pulp.

9. Jan. 22, 1898.   A fresh bullock's heart, still surrounded by the lung, which is not inflated perfectly.   The right ventricle faces the shot which is aimed at its centre.   The bullet enters with full velocity, at 5 feet from the muzzle.   The entrance opening in the wall of the right ventricle is 3.5 cm. long and 2 cm. broad, exposing the muscular substance. There is one fissure running from the lower border of the opening towards the apex, 4 cm. long and in part extending through the entire thickness of the muscular wall.   The exit is an irregular large-sized hole, freely exposing the inner cavities of the organ, showing that a portion of the septum has been carried away, and a portion of the heart is in shreds. The same shot pierced the lung behind the heart, which apparently suffered from the explosive effect produced in the heart.   The entrance is 4 cm. in diam., the exit 10 cm. long and 4 cm. broad.   Part of the muscular substance of the heart was carried right through the lung, being found scattered over the canvas cloth hung up behind it.

10.   March 12, 1898.   A calf's heart, just removed and in a state of firm contraction, having evidently stopped beating in systole, suspended by a bandage wound around the origin of the great vessels so that both the right and left ventricles were in sight.   The bullet, with a velocity of 1,163 feet, fired 10 feet from the heart, passed through exposed portion of the left ventricle about 5 cm. above the apex, making a

round, clean entrance, 6 mm. in diam. The exit was found over the dividing line between the right and left ventricle, included a portion of the septum, and measured 8 mm. in diam., rather oval than round; the entire track is smooth and shows not the least injury to any other portion of the heart.

Reviewing the results obtained from the above series of shots, we find, in the first place, that the shot through the brain of the young calf, when compared to injuries of other parts produced with the same velocities, is altogether unique and exceptional. Such an injury, produced in man, would have elicited not only a favorable prognosis from the beginning, but would have ended in a good recovery. Very interesting, also, are the fine shades of difference to be noticed between the injuries of the liver and those of the kidneys, as produced by the same velocities. The relatively larger amount of fluids contained in the liver over that contained in the kidney is quite sufficient to explain this difference. The high degree of explosive effect produced by the highest velocity bullets becomes less great as the velocity decreases, and ceases altogether when the velocity has reached 1,000 feet p. s. We may, therefore, conclude that the limit for the production of explosive effect on viscera by our bullet lies somewhere in the neighborhood of 1,000 feet, which velocity will probably be found to lie near a point corresponding to a distance of a thousand yards from the muzzle of a gun fired with full charges of ammunition.

B. BONES AND JOINTS.

Under this head I will describe a few shots, through each type of bone, made with different velocities. Since the material in this series was chiefly derived from a young ox and a calf, both of which had just been killed by a shot through their brains, other injuries will be mentioned incidentally.

1. *Lower jaw.* — A full-velocity bullet struck and went through both rami of the lower jaw of a young ox, 90 feet from the muzzle. The skin entrance measured 10 mm.

in diameter, had serrated edges, and a narrow margin around the opening was deprived of hair. The bone entrance was round and measured 6 mm. in diam. The exit, on the right side of the animal's jaw, showed a skin wound, 1.5 cm. long and 1 cm. broad, with ragged edges. Underneath the skin is felt a swelling, caused by bone dust and semi-coagulated blood. Culling off the skin from the left side of the lower jaw, or the entrance, a longitudinal slit-like opening in the fascia is noticed and which measured 2.5 cm. in length and 1 cm. in breadth. This fascia, also, showed some bulging due to a collection of bone dust and blood between it and the bone. In the bone underneath this tumor was found a round opening, 6 mm. in diam., but widening to 10 mm. at the exit from the left side of the lower jaw; here, also, are found numerous fine spicules, pointing in the direction in which the shot went, and still adhering to the periosteum. On the right side the bullet had simply carried away a small square piece of bone near the ankle, leaving an irregular hole in the bone and causing a tumor-like protrusion made up of bone dust and blood.

2. *Lower jaw.* — A bullet of 1,500 feet velocity, aimed at the lower jaw of a cow. The head was so disposed that the bullet had to pass through both sides of the bone at 5 feet from the muzzle. The bullet entered at a point midway between the ankle and the teeth of left side, causing an entrance 6 mm. in diam., with an exit of 16 mm. in diam.; passing on through the right side of the jaw, it gave rise to an entrance of 8 mm. in diam., and an exit of 32 mm. in diam. The track was decidedly funnel-shaped and the marrow was exposed. This shot shows the influence of gradually increasing deformity of bullet on size of wound.

3. *Ilium.* — A 6-mm. bullet, with a velocity of 750 feet p. s., entered the flat surface of the ilium, 5 feet from the muzzle, causing an entrance of 6 mm. in diam. and an exit of 8 mm. in diam. The injury is a clean perforation without any fissuring or splintering.

4. *Shoulder plate.* — A bullet with a velocity of 750 feet p. s. entered supra-spinous portion at a distance of 5 feet

from the muzzle, giving rise to an entrance of 6 mm. and an exit of 7 mm. in diam. without splintering or fissuring.

It will be noticed, then, that even in flat bones in which clean perforative injuries with hard-jacketed bullets are the rule, with even the highest velocities, with our bullet these are obtained only with the lowest velocities.

5. *Neck.* — A full-velocity bullet struck the neck of a young ox, 90 feet from the muzzle, about midway between the head and shoulders. The skin entrance was a typical hole of 7.5 mm. in diam., the exit, not exactly in line with and opposite to the entrance, was an irregular opening, 22 mm. long and 15 mm. wide. The subcutaneous tissues, immediately adjacent to the exit, are distended and crowded with bone dust and blood. The margins of the wound are angular, with three fissures starting in various directions and each 1 cm. long. Small detached pieces of the mantle and of the lead from the projectile were found mixed with the sandy contents of the tumor-like protrusion underneath the skin in the immediate neighborhood of the opening. The finger, which is introduced without difficulty, touches the broken surfaces of vertebræ at the bottom of the wound. On the left side, or the side of the entrance of the bullet, dissection reveals a narrow track leading to a tumor of the size of a goose's egg, enclosed in white fibrous tissue, and through the centre of which there is an opening or passage filled with coagulated blood. Incising this tumor, we find it filled with semi-coagulated blood and in the centre of it, and passing in a longitudinal direction, a large vein is discovered which is empty, showing a lozenge-shaped opening without, however, having lost its continuity. The tumor, in other words, is what is generally known as a peri-vascular hæmatoma. Further dissection showed that the bodies of two adjacent vertebræ were broken into several pieces, and parts of these, partially ground up into bony detritus, are lining the track beyond and leading towards the exit on the other side. The middle of the track was several times more spacious than even the exit opening in the skin; the bony contents were grayish discolored from lead, and contained also small pieces of copper from the projectile.

6. *Wrist.* — A full-velocity bullet struck the wrist of a young ox, 90 feet from the muzzle. Typical entrance. Exit, on opposite side, is 3 cm. long and 1.5 cm. wide, its edges are jagged and torn; there is a tumor-like subcutaneous swelling, packed so full of bone sand and coarse splinters that the finger cannot be introduced. Several small pieces of the projectile were found mixed up with the mass.

7. *Ankle.* — A bullet with a velocity of 750 feet p. s. entered the ankle-joint of a cow at a distance of 5 feet from the muzzle of the gun. The entrance in soft parts was smaller than the diam. of the projectile, and some bony detritus could be seen through it. At first no exit could be found, but on searching further an opening was discovered, corresponding in size to the diam. of the bullet, but at right angles to its line of entrance and in a plane with it. On the same side of this opening, on the floor of the room, was found the lead of the bullet bent so as to form a quarter circle. Opening the joint, the empty jacket was recovered, embedded in a partly broken cuboidal bone. The rear end of the lead, found on the floor, fitted well into the jacket of the projectile found in the joint.

8. *Epiphysis of femur.* — A full-velocity bullet entered the outside of the knee-joint of a young ox, at a distance from the muzzle of 90 feet. There was a typical skin entrance. The adjacent portions of both femur and tibia were completely ground up into bony detritus, filling the cavity of the joint. Two long and deep fissures pass upward in femur, the lower end of which presents three tooth-like spines 1 cm. in length. The narrow cavity is empty and glistening. The blood vessels are completely destroyed, and there is not the slightest trace to be seen of the articular surfaces. The entire joint cavity is simply packed solidly with detritus which, in part, is protruding through on the side opposite to the entrance, looking into the body of the animal. The projectile is in pieces, and mixed with the detritus filling up the cavity of the joint.

9. *Epiphysis of tibia.* — A bullet with a velocity of 1,500 feet struck the epiphysis of the tibia of a cow at a distance

from the muzzle of 5 feet.   Both the entrance and the exit
are smaller in diameter than the bullet.   Neither opening
shows the least sign of splintering.   A wire passed through
the track made by the bullet produced a small amount of
moist bone dust, which looks reddish, and feels sandy to the
touch.

10. *Metaphysis of tibia.* — A bullet of a velocity of 1,500
feet p. s. struck the tibia of a cow about 4 cm. from the
head, and at a distance from the muzzle of 5 feet.   The
entrance was typical, and of the diameter of the projectile.
From the entrance in the bone, and extending downward, may
be seen a broad, flat bony lamina, 6 cm. long, 15 mm.
broad, raised above the surface of the surrounding bone,
immovable, and tightly adhering to it.   Exit in the bone, 7
mm. long and 5 mm. broad, shows not the least splintering
or fissuring.   At a distance of 2 cm. from this opening,
however, there commences a fissure 75 mm. long, slightly
elevated, not movable, exposing the narrow cavity, and pass-
ing in the direction of the diaphysis of the bone.

11. *Metaphysis of tibia.* — A bullet of a velocity of 1,000
feet p. s. entered the lower metaphyseal portion of a tibia
from a cow at a distance from the muzzle of 5 feet.   The
entrance opening in the bone is of the diam. of the projectile,
but forms the starting-point for a fine fissure in the most su-
perficial layer of the bone, 8 cm. long.   The exit is an ovoidal
opening, exposing a funnel-shaped cavity in the substance of
the bone, through which the entrance opening is easily seen.
A fissure 1.5 cm. in length passes from the exit in a direc-
tion towards the diaphysis of the bone.

12. *Diaphysis of tibia.* — A bullet with full velocity
entered the leg of a young ox, passing through the centre
of the diaphysis of the tibia, at a distance from the muzzle of
90 feet.   The skin entrance is a typical hole of the diam. of
the projectile.   The exit is a long rent in the skin, through
which splinters of bone and shreds of muscles protrude.   The
bone is completely broken in continuity.   Several pieces of
bone, 3 and 7 cm. long respectively, are easily removed
through this opening, and many smaller pieces are driven

into the neighboring tissues. Contents grayish discolored, and mixed with parts of the projectile.

13. *Diaphysis of tibia.* — A bullet of 1,500 feet velocity passed through the centre of the diaphysis of the tibia of a cow, at a distance of 5 feet from the muzzle of the gun. The result was a butterfly fracture (Bornhaupt), though not a typical one, being accompanied with long fissures and extensive splintering. The entrance in the bone is 1 cm. in diam., the exit 6.3 cm. The splinters remain adhering to the periosteum, exposing a portion of the marrow cavity of the size of a pigeon's egg. The cavity is lined with small pieces of lead, its contents grayish discolored.

14. *Diaphysis of tibia.* — A bullet moving with a velocity of 750 feet p. s. entered the centre of the diaphysis from a cow. The entrance in the bone is 10 mm. in diam., rather quadrangular, and from each corner of the quadrangle there starts a deep fissure; these four fissures pass upward and downward, two on each side of the cylindrical bone, and diverging as they pass, also exposing the marrow and comprising the entire thickness of the bony cortex. The upper and outer of the four fissures is 6 cm. long, the lower and outer 3 cm. long; the upper inner fissure is 5 cm. long, and the lower inner 4 cm. long. The exit presents a longitudinal opening, 14 cm. long and 3 cm. broad, exposing the marrow. Several pieces of bone hanging into the cavity by the periosteum.

From the accounts of the injuries on bones we find that the injuries produced by the highest velocities are simply terrible, and those produced by the lowest, far from benign. Although the injuries which have been described in the preceding pages as occurring under different and varying conditions of experimentation on animal structures and organs cannot be directly applied to the living human subject, they have been selected from a very large number, and will be found of material value. It is not within the scope of this paper to draw any very detailed and far-reaching conclusions as regards the treatment of the injuries as they are likely to occur in the human subject, but, whatever else may be

brought to light by future experimentation on the human cadaver or by accidents occurring either during peace or on the field of battle and produced by our projectile, one thing is certain; namely, that the explosive zone has been extended and its penetrative power lessened, owing to the softness of the jacket and the consequent ease with which the bullet is deformed when striking bones or other hard substances.

It may be assumed with a fair show of reason that such injuries as will probably be produced in the human subject by our projectile will influence the methods of treatment both in the rear of the fighting-line and in the hospitals afterwards, in that they will require the treatment laid down for "near-shots" (Nahschüsse), that is to say, they must from the very beginning be treated as infected injuries. Owing to the further fact that the projectile often goes to pieces, portions of its copper jacket and of its lead lining the track, we may reasonably expect that amputations will have to be done more frequently, and that the percentage of mortality will be higher, no matter how well equipped the hospital nor how skilful and experienced the surgeon.

A MODIFICATION OF THE FERMENTATION TUBE FOR BACTERIOLOGICAL WORK.

By HIBBERT WINSLOW HILL, *Director.*

(*From the Laboratory of the Boston Board of Health.*)

The work of Theobald Smith and others has shown the high value which attaches to the fermentation tube, in the form heretofore employed, for the study of bacteria. For the exact determination of gas production, the fermentation tube is superior to any other method yet devised; but, in addition to this, one obtains in testing pure cultures not only a quantitative and qualitative determination of the gas produced, but also an accurate determination of the relation of the organism to oxygen, and of "the appearances of growth" in broth presented under both aërobic and anaërobic conditions. The determination of the different chemical changes occurring in the broth itself as a result of growth under the aërobic and the anaërobic conditions obtaining respectively in the open and closed divisions of the tube is also useful.

The determination of these changes has heretofore been made by examining the liquid in the bulb first, then removing this entirely, and finally admitting air to the closed branch from below. As the air passes upward the liquid in the closed branch passes into the bulb, whence it may be removed for examination. This method has yielded good results, but nevertheless it has been my desire for some time to devise a tube which would permit a direct examination of the liquid in the closed branch without disturbing the relations of the two portions. After one or two attempts I have succeeded in accomplishing this end. It is a very simple matter. Practically, the new modification consists in replacing the closed upper end of the ordinary fermentation tube by a conical stopper, the surfaces in contact being carefully ground so that they fit each other snugly. The stopper is made thimble-shape, to avoid the danger of cracking under high temperatures which might affect a solid stopper. Otherwise

this tube varies from most of those on the market chiefly in being made to conform more exactly to the specifications of Dr. Smith regarding the capacity and diameter of the closed branch and the diameter of the connecting arm. In 1897 I had the bulbs of my fermentation tubes made larger than those of the ordinary tube, so that they contained twice as much liquid as the closed branch. This improvement has been retained in the present model. It is designed to prevent wetting of the cotton plugs in sterilization. The free opening into the bulb is generally too small in these tubes as they are placed on the market. It should be large enough to admit an ordinary 10 cc. pipette. These tubes have been tested carefully and in my hands are a decided success. To examine the liquid in the closed branch when no gas has been formed, the cotton plug is removed from the bulb opening and replaced by a sterile rubber stopper, fitted snugly. The stopper of the closed branch may then be removed and the contained liquid exposed. With care and a little practice this stopper may be replaced, if desired, without spilling any of the liquid and without including any air. If some of the liquid is removed for titration it is sufficient to fill the tube up to its first level with sterile water or broth before replacing the stopper. In the case of a gas-forming bacilli a similar method is followed. The gas is, of course, lost on removing the stopper, so that if a qualitative determination of the gas is required it is better to have a duplicate culture for this purpose, carrying out the determination in the ordinary way.

The moveable stopper permits a more ready and thorough cleaning of the tubes and simplifies the process of filling them, even if no other advantages are gained.

The rack in which the tubes are supported was also made to my design, and has proved a very satisfactory method of handling these unavoidably awkward contrivances. It is made of metal without solder, and can be sterilized with the tubes, either in the oven or in steam.

Surfaces in
contact ground.

20 cc.

Capacity
50 cc.

.5 cm.
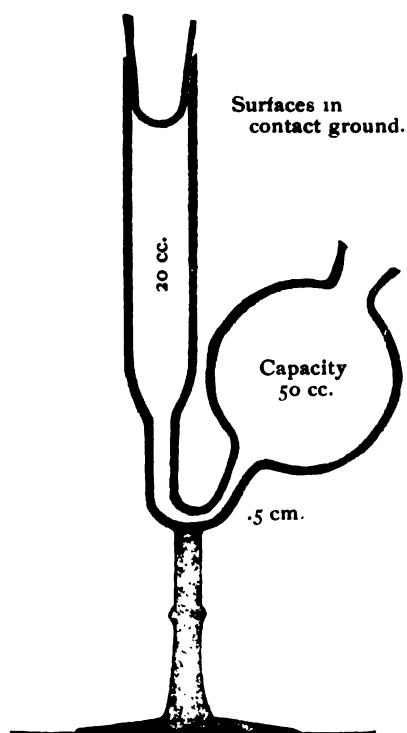
FERMENTATION TUBE, with movable top for closed branch.

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When *desired*, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished *free* to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on February 21 and March 21, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

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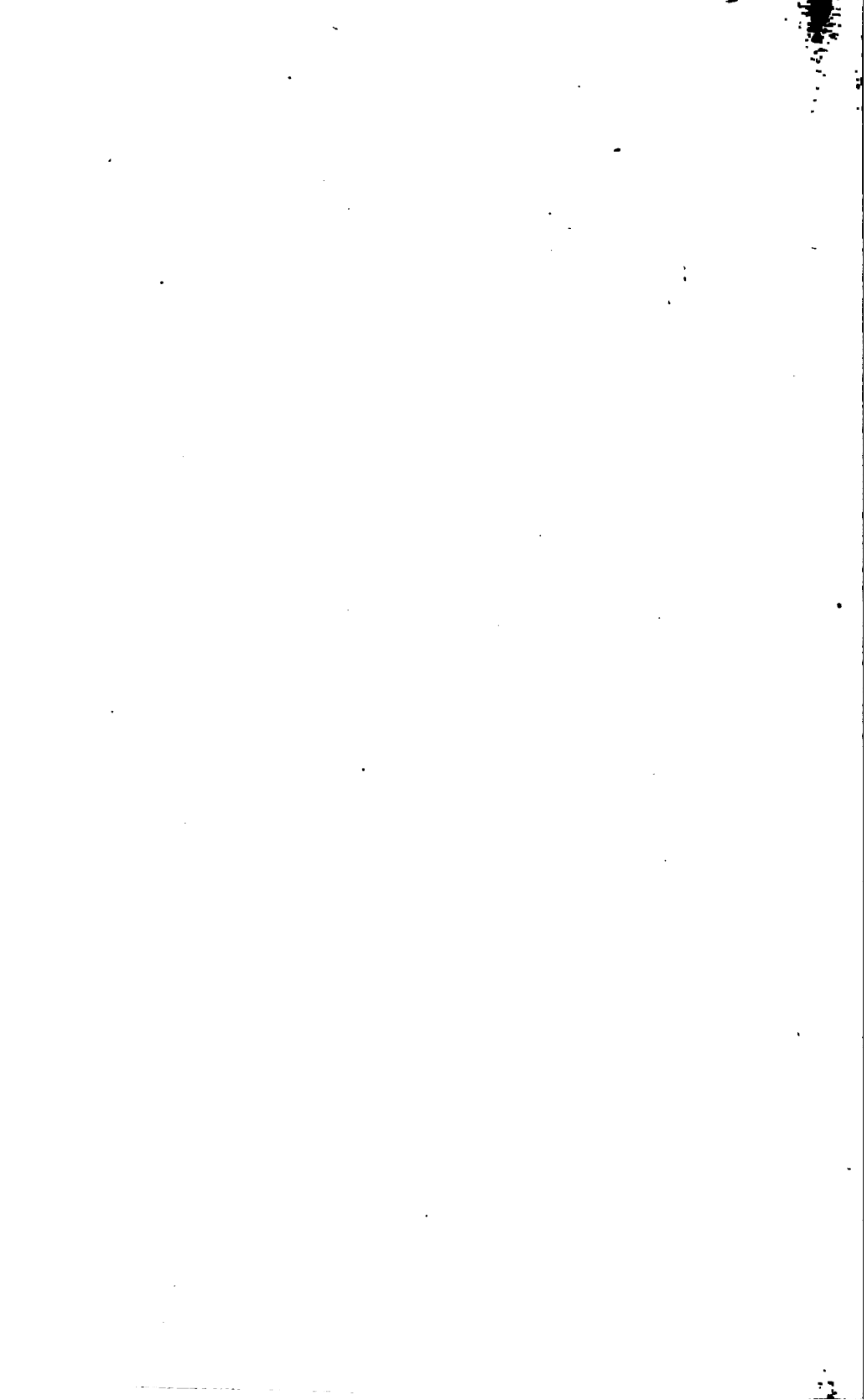
OBSERVATIONS UPON THE ELASTIC TISSUE OF CERTAIN
HUMAN ARTERIES.

GEORGE BURGESS MAGRATH.

(*From the Sears Pathological Laboratory.*)

I.   Introductory.
II.   Method.
III.   Results.
IV.   Conclusions.

I. INTRODUCTORY.

The study, of which the following is an account, was under-
taken for the purpose of determining the structure and the
distribution of elastic tissue in the arteries of the human body,
preliminary to an investigation of the changes present in that
tissue under certain abnormal conditions, notably arterio-
sclerosis and aneurism.

Since the introduction into histological technique of differ-
ential stains for elastic tissue, numerous observations have
been made upon these changes, but it does not appear that
any very comprehensive study of *normal* arteries by the aid
of the newer methods has been hitherto undertaken.   *Grün-
stein,*[1] in a recent paper setting forth the results of his investi-

[1] Ueber den Bau der grösseren menschlichen Arterien in verschiedenen altersetufen.
Arch. f. Mik. Anat., Bd. xlvii, S. 583.

gations into the structure of the larger human arteries, incidentally describes the elastic tissue of the aorta, and of the common carotid, the subclavian, and the common iliac arteries, in individuals of various ages.   He demonstrated this form of tissue by means of orcein and Unna's methylene blue. He states that the elastic tissue of the aorta exists in the form of concentric fenestrated layers, or lamellæ, between which there is a system of interlamellar fibres running in various directions; and that arteries of a given size have the same general type of structure.   This latter opinion is shared in by *Bonnet*.[1]

Grünstein's paper and the observations upon normal structure occasionally noted by investigators of the pathological changes in the arteries constitute the chief sources of recent knowledge upon this subject.

The present study was directed to the acquisition of additional data by the examination of arteries varying widely in size and in anatomical distribution, and at different periods of life.   From it there have been derived a fuller understanding of the structure of the elastic tissue elements of the aorta and of various arteries, and the conclusion that the distribution of these elements is not uniformly the same for all vessels of a given size, but that the number and the arrangement of the elastic fibres do not of necessity bear any relation to the calibre of the artery.

II. METHOD.

ARTERIES SELECTED FOR STUDY. — The object of this investigation being to obtain as comprehensive a view as possible of the distribution of elastic tissue in the walls of the vessels of the arterial side of the circulatory apparatus, arteries were selected for study which present the widest possible variations in size and in anatomical distribution.   In order to add to the completeness of the inquiry material was taken from individuals at different periods of life.

The vessels so selected comprise:

(1.) The aorta.
(2.) Basilar artery.

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[1] Bonnet: Ueber den Bau der Arterienswand.   Deutch. Med. Woch., xxii, 2.

(3.) Common carotid artery.
(4.) External carotid artery.
(5.) Internal carotid artery.
(6.) Cerebral arteries.
(7.) Cœliac axis.
(8.) Coronary artery.
(9.) Femoral artery.
(10.) Hepatic artery.
(11.) Common iliac artery.
(12.) External iliac artery.
(13.) Internal iliac artery.
(14.) Innominate artery.
(15.) Internal mammary artery.
(16.) Inferior mesenteric artery.
(17.) Superior mesenteric artery.
(18.) Radial artery.
(19.) Renal artery and its terminal arterioles.
(20.) Splenic artery and its terminal arterioles.
(21.) Subclavian artery.
(22.) Vertebral artery.

The *ages* represented range from eight months *in utero* to forty-six years.

In all, tissue was collected from twenty-seven cases. Of the fourteen selected for study the ages were:

(1.) Eight months *in utero*.
(2.) Four months.
(3.) One and a half years.
(4.) Two years.
(5.) Three years.
(6.) Four years.
(7.) Five years.
(8.) Six years.
(9.) Nine years.
(10.) Nineteen years.
(11.) Twenty years.
(12.) Twenty-six years (two cases).

(13.) Twenty-six years.

(14.) Forty-six years.

Specimens of *all* the arteries named were not available in every case, but from two to ten preparations of each vessel were obtained.

No especial account has been taken of *sex*.

SOURCES OF MATERIAL. — The material for this investigation was derived from the autopsy rooms of the Boston City Hospital; the Boston City Hospital, South Department; the Massachusetts General Hospital; and the Long Island (Boston) Hospital. The cases from which specimens were taken were selected from about three hundred post-mortem examinations, whereby it was possible to choose material with a minimum post-mortem interval. It is needless to state that the tissues were taken from such cases only as presented no evidence whatever of any abnormal condition of the arteries.

In collecting tissues care was exercised to take the specimen for preservation in each instance as nearly as possible from the same point in the course of the vessel.

HISTOLOGICAL TECHNIQUE. — The tissues were hardened in 70 per cent. alcohol, followed in twenty-four hours by 80 per cent., and in forty-eight hours by 95 per cent. alcohol, and imbedded in celloidin.

This method of fixing and hardening the tissue was found to give better results with the stain employed than those obtained by the use of Zenker's fluid.

Sections 8 to 12 μ in thickness were cut in a variety of planes: Arteries in a transverse, a longitudinal, a tangential, and occasionally in an oblique plane; the aorta in transverse and longitudinal planes, and also in a plane parallel with the surface.

Sections in this plane were made from rectangular pieces about 5 × 8 mm. cut from the wall of the aorta, flattened out in the fresh state upon pieces of glass of the same size, held in place by means of silk thread, and imbedded in this position. From material thus prepared serial sections were readily obtained, thereby facilitating the study of the aorta in this plane at various levels.

Method of Staining. — The method of staining employed in this study depends upon the affinity of phosphotungstic acid hæmatoxylin for elastic tissue. This stain, which was introduced by *Mallory* in 1897, is prepared as follows:

Hæmatoxylin crystals .   .   . . 0.1 part ·
Phosphotungstic acid .   .   .   1.0 part
Water   .   .   .   .   .   99.0 parts

The resulting solution is ready for immediate use.

The best results have been obtained by the use of phosphotungstic acid made by Merck previous to 1898. Acid made after that date requires the addition of an oxidizing agent to produce a stain with specific action upon elastic fibre.

Sections treated in the following manner:

(1.) Mallory's phosphotungstic acid hæmatoxylin 18–24 hrs.
(2.) Water to remove excess of stain.
(3.) 95% alcohol (to dehydrate and differentiate).
(4.) Oil of bergamot.
(5.) Mounted in Canada balsam.

Show — nuclei stained faint purple; smooth muscle fibre pale pink; connective tissue red, or grayish-red; endothelium uncolored or faint yellowish-brown; elastic tissue deep blue. In good preparations the finest fibrillæ of elastic tissue are sharply defined, while the thick plates of this tissue are not so deeply stained as to interfere with a close study of their structure.

This method of staining has the marked advantage over other differential stains for elastic tissue — notably orcein, and Manchot's fuchsin method — of very great simplicity, no decolorizing, contrast staining, or special method of mounting being required. The results yielded by it seem equal if not superior to those obtained by the best of the other methods now in use.

III. RESULTS.

A brief description of each of the cases from which the following data were derived may be found in *Table 1 :*

1. Aorta.

The aorta was studied at various points: at the ascending, the transverse, and the descending arch, and at the level of the cœliac axis.

The elastic tissue of the aorta is usually and correctly described as consisting of a more or less distinctly marked inner elastic plate composed of two layers or leaves, numerous concentric lamellæ of elastic tissue placed at about equal distances from each other throughout the middle coat, elastic fibres running in various directions between these lamellæ, and a few irregularly disposed fibres in the outer coat. Seen in cross-section the lamellæ appear as continuous, wavy, more or less concentric lines, at times interlacing, and the interlamellar fibres as fine thread-like processes. The inner layer of the internal elastic plate consists of longitudinal fibres which in this section have a punctate appearance. Seen in longitudinal section the lamellæ appear as straight, more or less parallel broken lines or punctate segments, with short processes running in various directions.

Serial sections cut parallel with the inner surface of the aorta greatly facilitate an understanding of the character of these lamellæ and of their relation to the interlamellar fibres.

The only important point of difference in the character of the elastic tissue at various levels of the aorta concerns the inner elastic plate. In the ascending and the transverse portions of the arch no definite inner plate can be distinguished. In the descending arch it is present, and continues through the thoracic and abdominal portions of the vessel.

For purposes of description the cases studied will be divided into groups representative of:

    (a.) Infancy.
    (b.) Childhood.
    (c.) Maturity.

Before considering the aorta during the earlier years of life note may be made of the characteristics of the elastic tissue presented in the fœtal aorta. In an eight-months'

fœtus the lamellæ number forty; are placed near together; crowded close, and rather flat in the outer third; somewhat corrugated on the inner half of the wall. There is little or no elastic tissue in the adventitia.

(1.) *The Aorta in Infancy.*[1] — (Birth to six years; 8 cases.)

a. Ascending Arch. — *Cross-section* shows about 40 lamellæ; fine; placed closely together, with but few anastomoses.

Longitudinal section shows the innermost lamella to be composed of fibres having a longitudinal direction.

Flat sections, i.e., parallel to the inner surface of the aorta, show the elastic tissue to consist of plates and a thick branching network, the latter derived from processes originating at the edges of the plates, the trend of the fibres being circular to the vessel (except that of those close to the intima, corresponding to the internal elastic plate) which are longitudinal, running athwart the others. In the outer half of the media the elastic tissue presents the form of more definite plates fenestrated with small round or oval openings, and richly branched. At the junction of the media with the adventitia this plate form is lost in a thick branching network of relatively fine fibres, whose course is irregular, many of them passing radially outwards. The adventitia presents a few irregularly directed fibres.

b. Transverse Arch. — Sections cut in all three planes show essentially the same characteristics as those present in the ascending arch. .

c. Descending Arch. — In this portion of the aorta the innermost of the lamellæ becomes rather distinctly demarcated from the others. In longitudinal section, to the inner side of the more prominent circular fibres are to be distinguished fibres having a direction parallel to the long axis of the vessel. Flat sections show these fibres in places closely packed together, constituting approximately a plate of elastic tissue, with numerous fenestrations.

d. Thoracic and Abdominal Portions. — The number of

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[1] Pl. I., Fig. 4.

lamellæ in these portions of the vessel is rather less than
that in the arch.   The inner elastic plate is present as a
definite lamella, the processes of which are distinctly longi-
tudinal in direction.   There are present in the sub-endothe-
lial connective tissue a few fine fibrillæ running in a variety
of planes.

The adventitia presents in its inner portion elastic fibres
directed longitudinally, in its outer portion fibres having a
more circular direction.

(2.)   *The Aorta in Childhood.* — (Seven to nineteen years;
2 cases.) — The general morphological characteristics pre-
sented by the elastic tissue in the aorta of infancy are found
at a later period of life.   The average number of lamellæ
appears to be rather less in childhood than in infancy.   The
lamellæ in this period present the form more of homogeneous
plates than of layers of closely placed fibres.   The openings
in these plates are distinctly larger than those present in the
lamellæ of the infant aorta, and the meshwork of the inter-
lamellar fibres somewhat coarser.

Serial sections cut at various levels of the aorta, in a plane
parallel with that of its inner surface, show plates or " islands "
of elastic tissue, fenestrated, with branching processes extend-
ing from the edges and apparently from the surfaces as well,
the long axis of the plates and the direction of the processes
being circular or transverse to the long axis of the vessel.
The fibres of these processes form a meshwork in the inter-
lamellar spaces, the processes of one plate anastomosing with
those of the adjoining plates.

(3.)   *The Aorta in Maturity.* — (Twenty-six to forty-six
years; 4 cases.) — Within the limits of this period the elastic
tissue of the aorta presents rather marked variations in char-
acter.   Below the age of about thirty the lamellæ and inter-
lamellar fibrous meshwork do not differ materially from those
structures as present in the aorta of the latter part of child-
hood.   In the case forty-six years of age there is evidence
of a distinct difference in the character of these elements.
The fenestrations in the elastic plates are large, so that the
resemblance to plates is in great measure lost, the appearance

being that rather of a coarse lattice-work.   This is well dem-
onstrated by serial sections parallel with the surface of the
aorta,[1] which show through the greater part of the thickness
of the aortic wall a meshwork of elastic fibres with only here
and there a suggestion of definite " islands " or plates.   In
this case the relation of the lamellæ to the interlamellar
fibrillæ is somewhat more apparent than it is in other instances,
and in " flat " sections the interlamellar meshwork is scarcely
to be distinguished from the lamellæ proper.   The elastic
fibres are somewhat coarser and heavier in the aorta of ma-
turity than they are in the aorta of earlier life.

In no individual above forty-six years of age, among the
three hundred cases examined upon the autopsy table during
the collecting of material for this investigation, was there
evidence, macroscopically, of a perfectly normal aorta; in
consequence the study of cases was not continued beyond
this age.

The results of the investigation of the elastic tissue of the
aorta may briefly be summarized as follows:

(1.) Elastic tissue exists in the aorta in the form of cir-
cular concentric lamellæ, and interlamellar fibrillæ in the
media, a part of it occurring at and below the level of the
descending arch in the form of an inner elastic plate (anal-
ogous to that of certain arteries), the internal fibres of which
are longitudinal; irregularly directed fibrillæ in certain por-
tions of the sub-endothelial connective tissue of the *intima;*
and fibres, the innermost longitudinal, the outer circular, in
the *adventitia.*

This is in accordance with previous observations, notably
those of Grünstein.

(2.) The lamellæ are homogeneous bands of varying
thickness, pierced with round or oval openings, continuous
laterally in the aortic wall, extending for varying distances
longitudinally, with numerous branch-like processes derived
from their edges, and to some extent from their surfaces,
these processes running in various directions in the inter-
lamellar area, the processes of one lamella becoming en-
meshed with those of adjoining lamellæ.

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[1] Pl. I., Figs. 1, 2, and 3.

(3.) The interlamellar meshwork of elastic fibres does not constitute a system separate from the lamellæ, but is shown by sections cut in the plane of the inner surface of the aorta to be derived from the processes of the lamellæ.

(4.) The character of the elastic tissue lamellæ varies in different periods of life:

In earlier life the lamellæ are more or less fibrous, their fenestrations are small, their processes fine, their proximity close.

In a middle period they are more nearly homogeneous plates.

In later life they are pierced with large openings, constitute a lattice-work, and their processes are relatively coarse.

2. Arteries.

For convenience in description the arteries included in this study may be grouped according to their relative size.

The absolute dimensions of the vessels cannot be determined by any measurements made after the tissue is hardened, but for purposes of comparison the diameters may be reckoned from measurements of the transverse sections after they are stained and mounted.

Measurements thus made enable the grouping of the arteries investigated as follows:

Group I.
Innominate,
Common iliac.

Group II.
Cœliac axis,
Common carotid,
External iliac,
Renal,
Superior mesenteric,
Splenic,
Subclavian.

Group III.
Axillary,
Femoral,
Internal iliac.

Group IV.
Brachial,
Femoral,
Hepatic,
Internal iliac,
Mesenteric,
Radial,
Renal — smaller branches,
Splenic — smaller branches.

Group V.

| Basilar, | Coronary, |
| Cerebral, | Vertebral. |

GROUP I.

(1.) *Innominate Artery.* — The elastic tissue of this vessel consists of, (*a*) concentric lamellæ situated in the *media*, presenting the same characteristics as the lamellæ of the aorta, from thirty to forty in number, placed at about the same distance from each other; (*b*) a not very sharply defined inner elastic plate, generally distinguishable into two layers, the innermost of which is a fibrous meshwork, the fibres of this running in a longitudinal direction; and (*c*) elastic fibres in the *adventitia*, not very numerous, the inner fibres longitudinal, the outer circular and radial. Between the lamellæ there are a few fibres of elastic tissue running in various directions, apparently originating as processes from the lamellæ, but not constituting any very definite meshwork.

The study of this and other arteries is facilitated by the use of tangential and oblique planes of section, which place the elastic tissue elements in a great variety of positions.

These characteristics appear to hold true for all periods of life; earlier in life the lamellæ are placed somewhat more closely together, and the elastic fibres are finer than in the adult vessel.

(2.) *The Common Iliac Artery.* — The structure and the arrangement of the elastic tissue of this vessel are very similar to those of the innominate artery. The internal elastic plate consists of a prominent band of circular fibres constituting the outer layer of this plate, with an inner layer made up of finer longitudinal fibres. At the outer limit of the media the elastic tissue is composed mainly of fibres, many of them radial, forming an irregular meshwork; there is no definite external plate, the elastic tissue of the *media* merging without change into that of the *adventitia*.

There are no marked differences in the elastic tissue of this vessel at different periods of life.

The lamellæ are placed more closely together in the artery

of the child than in the artery of the adult; and in the former the fibrillæ are somewhat finer than in the latter.

GROUP II.

(1.) *The Cœliac Axis.* — This artery presents an inner elastic plate consisting of a dense band of circularly disposed elastic tissue, pierced with numerous small round or oval openings. The media contains few or no elastic fibres in the form of lamellæ, the elastic tissue in this part of the vessel wall being composed of a few fine thread-like processes running in various directions between the smooth muscle fibres. The region between the media and the adventitia is occupied by an external elastic plate composed of two or three well-defined lamellæ, placed closely together, circular in direction, the outermost extending somewhat into the adventitia. The latter contains numerous longitudinal elastic fibres.

This artery in the adult presents no important differences from that in the child.

(2.) *The Common Carotid Artery.* — The common carotid artery presents the same type of structure as that seen in the innominate artery, *i.e.*, elastic tissue in the form of concentric lamellæ placed at equal distances from each other throughout the media, the innermost of which corresponds to an internal elastic plate, but is not especially prominent. The adventitia contains a few longitudinal and radial elastic fibres.

The structure of this vessel does not appear to vary in the different periods of life.

(3.) *The External Iliac Artery.* — The vessel has practically the same structure as regards the elastic tissue elements as the common iliac artery, with the exception that it presents a more or less sharply defined inner elastic plate, which in places may be seen to be composed of two layers, the innermost consisting of longitudinal fibres.

(4.) *The Renal Artery.*

(5.) *The Superior Mesenteric Artery.*

(6.) *The Splenic Artery.* — These three arteries may be described together, for, excepting the fact that the intima of

the splenic artery is relatively thicker than that of the other vessels, they present the same structural characteristics.

In these arteries seen in cross-section there is a sharply defined inner elastic plate, which in places may be seen to consist of two layers, at times slightly separated, the inner of the two made up of longitudinal fibres showing in this section as a row of dots close up under the endothelium of the intima, the outer layer homogeneous, fenestrated with small round or oval openings.   The media presents no lamellæ, but has scattered through it fine, delicate processes, and thin narrow plates of elastic tissue, not extending for more than a very short distance in the wall of the vessel.   Between the media and the adventitia and extending for some distance into the latter are from three to ten circular bands of elastic tissue, thick, dense, and placed close together.   This zone of elastic tissue has to its outer side a prominent layer of longitudinal elastic fibres which extends laterally through nearly the whole thickness of the adventitia.   These latter fibres are placed close together near the media, and in cross-section appear as a dense area of dots.   From the outermost of these longitudinal fibres originate fibrillæ having a radial direction, the whole forming a rich network of elastic tissue around the muscle layer of the wall of the artery.

·(7.) *The Subclavian Artery.* — The internal elastic plate is here well-defined, consisting of a prominent fenestrated band of elastic tissue, the inner part of which shows longitudinal fibres.   The media presents ten to fifteen concentric circular lamellæ, placed at uniform distances from each other throughout its entire extent.   These lamellæ are thinner than the inner elastic plate.   Oblique and tangential sections show these to consist here as elsewhere in the arteries of corrugated sheets of elastic tissue, of varying extent, and giving off anastomotic processes.   The lamellæ are placed more closely together in the outer than in the inner part of the media.   The adventitia presents a rich network of fibres of various sizes, chiefly longitudinal, some of them radial in direction.

GROUP III.

(1.) *The Axillary Artery.* — The internal elastic plate is a well-marked layer of elastic tissue, which, under high magnifying power, may be seen to present a more or less fibrous structure, the fibres and the long axis of the fenestrations being longitudinal in direction.

The media presents concentric lamellæ, about fifteen in number, similar in every way to those seen in the subclavian artery. Outside of the media (there is no well-marked outer elastic plate) and in the inner part of the adventitia there are longitudinally disposed, richly branched elastic fibres.

(2.) *The Femoral Artery.* — This artery presents a definite internal elastic plate; in one case (a nineteen-year-old male) this appeared to be double, a thin fibrous band lying to the inner side of a more prominent thicker layer. The elastic tissue of the media consists of six to ten circular lamellæ, placed close together, in the outer third of this portion of the wall. The inner half or two-thirds of the media contains only a few scattered fibrillæ. The adventitia contains longitudinal and radial elastic fibres.

(3.) *The Internal Iliac Artery.* — Besides a prominent internal elastic plate this vessel presents a thinner external elastic plate, circular in direction, dividing the media from the adventitia. Outside of this there are two or three circular lamellæ, and beyond these several layers of longitudinal fibres in the adventitia. The media presents a few — not more than three or four — thin, delicate lamellæ, with large fenestrations, and a few scattered thread-like fibres.

GROUP IV.

(1.) *The Basilar Artery.* — The elastic tissue of this vessel consists of an inner and an outer elastic plate, a few fine thread-like fibres in the media, and a thin layer of longitudinal fibres outside of the external elastic plate. It is a point worthy of note that the adventitia of this artery is of very slight relative thickness, its whole width being less than half that of the muscular coat.

(2.) *The Brachial Artery.* — The structure and the arrangement of the elastic tissue of this artery are in every way similar to those of the femoral artery, and do not require further description.

(3.) *The External Carotid Artery.*

(4.) *The Internal Carotid Artery.* — The external and the internal carotid arteries present the same type of structure. There is a definite internal elastic plate. The inner half of the media shows a few scattered delicate fibres; the outer half contains from eight to ten circular lamellæ, placed closely together. There are numerous longitudinal elastic fibres in the adventitia.

(5.) *The Inferior Mesenteric Artery.* — This vessel does not differ in respect to its elastic tissue from the superior mesenteric.

GROUP V.

(1.) *The Coronary Artery.* — The coronary artery of an infant one and a half years of age shows a definite internal elastic plate, presenting the familiar convoluted outline commonly seen in arteries of small size, a thin outer elastic plate; and a few thread-like fibres scattered through the media. The internal plate is homogeneous in structure, with very few processes, and pierced by small holes. There are a few longitudinal and irregularly disposed fibres in the adventitia.

This artery in a child six years old shows an intima equal in thickness to nearly one-half the thickness of the media. The internal elastic plate is a thin non-convoluted lamella composed of longitudinal fibres massed together, but not appearing as a homogeneous plate. Outside the media and extending for a slight distance into the adventitia is a delicate meshwork of longitudinal and radial elastic tissue fibres. There is little or no elastic tissue in the media.

The coronary artery of the adult shows a very slight amount of elastic tissue, present in a thin meshwork at the site of the internal elastic plate.

The marked thickness of the intima of the coronary artery in instances where there is no suspicion of abnormalities of

the other arteries suggests that its normal thickness is relatively greater than that of other vessels of the same size.

(2.) *The Hepatic Artery.* — The internal elastic plate is present as a definite layer of longitudinal elastic fibres. The media contains a few very fine fibrillæ of elastic tissue scattered through it. An outer elastic plate is composed of a circular lamella, outside of which are numerous longitudinal fibres, extending a short distance into the adventitia.

(3.) *The Internal Mammary Artery.* — This vessel presents a type of structure similar to that of the innominate and the common iliac arteries. It possesses a fairly well-marked inner elastic plate, but nothing corresponding to a definite outer elastic plate. The media contains from three to six lamellæ of elastic tissue, in the outer half of the muscular coat placed closer together than in the inner half. In the adventitia there are a few circular layers of elastic tissue, with, to the outer side of these, longitudinal fibres.

(4.) *The Radial Artery.* — This artery possesses a well-marked inner elastic plate. The media contains a few thin, scattered, thread-like fibres. The adventitia presents an inner circular and an outer longitudinal layer of fibres.

(5.) *The Vertebral Artery.* — This vessel is similar in practically all respects to the basilar artery.

GROUP VI.

Arterioles. — The arterioles of the brain, the liver, the spleen, and the kidney contain a slight amount of elastic tissue which so far as can be determined is limited to delicate fibres situated at the junction of the media with the intima, or corresponding to the inner elastic plate.

From the data obtained by the study of the elastic tissue of these arteries it is evident that with reference to the character and the distribution of this tissue there exist several types of structure, and furthermore that no one of these types of structure is peculiar to arteries of a given size.

The latter fact is well evidenced by the case of the inter-

nal mammary artery, a vessel resembling the innominate in structure, though very much smaller in size.

The types of structure may be classified as follows:

TYPE A.

[Plate II., Fig. 1.]

Elastic tissue present in the form of:

a. Concentric lamellæ throughout the media.

b. An inner elastic plate of various degrees of development.

c. Longitudinal and irregularly disposed fibres in the adventitia, few in number.

This type of arrangement resembles that of the aorta and is that found in the

(1.) Innominate artery.   (5.) Axillary artery.

(2.) Common iliac artery.   (6.) Internal mammary artery.

(3.) Subclavian artery.

(4.) Common carotid artery.

These vessels vary widely in size.

TYPE B.

[Plate II., Fig. 2.]

Elastic tissue present in:

a. Concentric lamellæ in the outer half of the media.

b. Fibres, thin, delicate, scattered through the inner half of the media.

c. An inner elastic plate which may be double.

d. A few longitudinal and other fibres in the adventitia.

This type of structure is seen in the

(1.) External carotid artery.

(2.) Internal carotid artery.

(3.) Femoral artery.

This type is transitional between the preceding and the following types.

TYPE C.
[Plate II., Figs. 2 and 3.]

Elastic tissue present in:

    a. A prominent internal elastic plate; this may occur in two layers, the inner of which is longitudinal.

    b. Thin, delicate circular bands and fibrillæ scattered through the media.

    c. An external elastic plate composed of one or more circular lamellæ at the outer limit of the media.

    d. An inner circular layer and an outer longitudinal and radial in the adventitia.

This type of structure occurs in the

      (1.) Brachial artery.
      (2.) Hepatic artery.
      (3.) Internal iliac artery.
      (4.) Superior mesenteric artery.
      (5.) Inferior mesenteric artery.
      (6.) Cœliac axis.
      (7.) Radial artery.
      (8.) Renal artery.
      (9.) Splenic artery.

These vessels present wide differences in calibre, *e.g.*, radial and superior mesenteric arteries.

TYPE D.
[Plate II., Fig. 5.]

Elastic tissue present in

    a. A thin, delicate internal elastic plate composed of longitudinal fibres.

    b. Fine circular fibres in the media; these may be absent (arterioles).

    c. A meshwork of longitudinal fibres outside the media and extending into the adventitia; this may be absent.

This type is exemplified in the

      (1.) Basilar artery.
      (2.) Cerebral artery.

(3.) Coronary artery.
(4.) Vertebral artery.
(5.) Arterioles.

The essential characteristics of these four types of structure may briefly be summarized:

Type A. — Elastic tissue abundant in the wall; scant around it. Arterial wall resilient rather than muscular. Adapted to withstand steady pressure.

Type B. — Intermediate between Type A and Type C.

Type C. — Elastic tissue scant in the wall; abundant around it. Arterial wall muscular rather than elastic. Adapted to contract under vasomotor impulse, at the same time to withstand pressure.

Type D. — Elastic tissue in minimum amount. Arterial wall muscular. Adapted to rapid changes of calibre under vasomotor impulse.

An inspection of the list of vessels exemplifying in the distribution of their elastic tissue Type A shows that they are functionally conducting mains, and not subject to changes in calibre.[1]

Similarly, the arteries representing Type C are seen to be distributing vessels, whose function postulates adaptability to changes in delivering capacity, and therefore in calibre.

And finally, in the arteries and arterioles constituting Type D are found the delivering channels in which physiological changes are most marked and rapid.

IV. CONCLUSIONS.

The conclusions resulting from this study may be briefly restated as follows:

(1.) The elastic tissue of the aorta consists of a system of richly-branched fenestrated bands or plates, circular in direction, except the innermost, which is longitudinal, and concentrically placed in the tunica media; and an inter-lamellar

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[1] The internal mammary artery, a vessel of only about 2 mm. diameter, might seem to be an exception to this; embryologically, however, it is a trunk of supply. — *Vid.* Minot: Human Embryology, p. 538.

meshwork of elastic fibres derived from the processes of these plates.

(2.) These structural characteristics are practically constant for different levels of the aorta.

(3.) The elastic tissue of the aorta of the child differs from that of the aorta of the adult in that the lamellæ or plates are placed more closely together, are more fibrous, thinner, and present smaller fenestrations, and the fibres and spaces of the interlamellar meshwork are smaller in the former than in the latter.

(4.) The elastic tissue of the arteries varies in character and distribution, justifying the recognition of several types of structure.

(5.) These structural characteristics are constant for different periods of life.

(6.) The distribution of elastic tissue in the arterial wall probably bears some relation to the function of the vessel.

TABLE No. 1.

No. Case.	Age.	Sex.	Interval Post-mortem.	Source.	Cause of Death.	Remarks.
1 ...	8 mos. in utero	♂	2 hrs.	....	....	Aorta only examined.
2 ...	4 mos.	♀	6 hrs.	B.C.H.		
3 ...	1.5 yrs.	♀	10 hrs.	B.C.H., S.D.	Diphtheria.	
4 ...	3 yrs.	♀	12 hrs.	B.C.H., S.D.	Diphtheria.	
5 ...	4 yrs.	♀	10 hrs.	B.C.H., S.D.	Scarlet Fever.	
6 ...	5 yrs.	♂	12 hrs.	B.C.H., S.D.	Scarlet Fever.	
7 ...	6 yrs.	♂	14 hrs.	B.C.H., S.D.	Diphtheria.	
8 ...	9 yrs.	♀	6 hrs.	B.C.H.	Appendicitis.	
9 ...	19 yrs.	♂	6 hrs.	B.C.H., S.D.	Diphtheria.	
10 ...	20 yrs.	♂	3 hrs.	B.C.H.	Typhoid Fever.	
11 ...	26 yrs.	♂	10 hrs.	L.I.H.	Pulmonary Tuber.	
12 ...	26 yrs.	♂	10 hrs.	B.C.H.	Pneumonia.	
13 ...	35 yrs.	♂	12 hrs.	M.G.H.	Typhoid Fever.	
14 ...	46 yrs.	♀	20 hrs.	B.C.H.	Abscess of Lung.	This case was frozen after death, and tissues were in a state of good preservation.

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DESCRIPTION OF PLATES.

PLATE I.

FIG. 1. — Cross-section of the aorta (transverse arch) of an adult, showing a portion of the media with its concentric lamellæ of elastic tissue. Zeiss 16 mm. obj.

FIG. 2. — Section of the aorta of a man 20 years old, parallel with the inner surface, made at a point about one-third the distance from the intima to the adventitia. The surface of one of the elastic plates is here shown with its fenestrations and branching processes. Zeiss 16 mm. obj.

FIG. 3. — Section of the aorta of a man of 35, made in the same plane as the preceding, showing the fenestrated lamellæ of the media at about its middle point, and their branching processes forming a meshwork. Zeiss 16 mm. obj.

FIG. 4. — Section of the aorta of a child 1½ years old, made in the same plane as the preceding, showing the latticed elastic plates of the media and the fine meshwork of interlamellar fibres derived from them. Zeiss 16 mm. obj.

PLATE II.

FIG. 1. — Cross-section of the innominate artery of a man 26 years old, showing the inner elastic plate, composed of two layers of elastic tissue, and concentric lamellæ of elastic tissue in the media. Zeiss 16 mm. obj.

FIG. 2. — Cross-section of the external carotid artery of a child, at its point of origin, showing: (a) A fenestrated inner elastic plate; (b) concentric lamellæ of elastic tissue in the outer half of the media; (c) the cut ends of longitudinal fibres in the adventitia. Zeiss 16 mm. obj.

FIG. 3. — Cross-section of the cœliac axis of an adult, showing: (a) An inner elastic plate; (b) fine elastic fibres in the media; (c) an outer elastic plate composed of several circular lamellæ. Zeiss 16 mm. obj.

FIG. 4. — Cross-section of the superior mesenteric artery, presenting the same characteristics as the preceding. Zeiss 16 mm. obj.

FIG. 5. — Cross-section of the coronary artery of a man 26 years old, showing an inner and an outer elastic plate, composed of thin circular bands of elastic tissue. Zeiss 16 mm. obj.

Fig. 1.

Fig. 2

Fig. 3.

Fig. 4.

MAGRATH — ARTERIES.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

MAGRATH — ARTERIES.
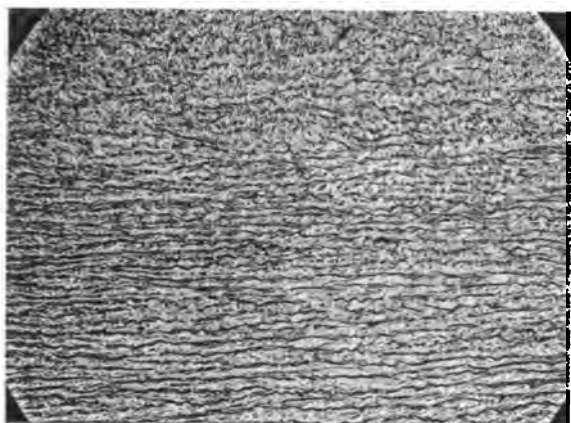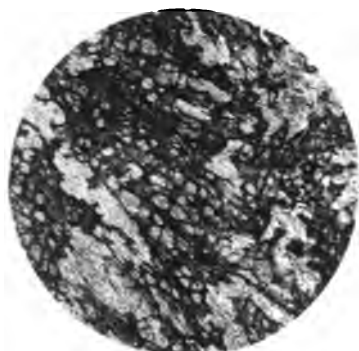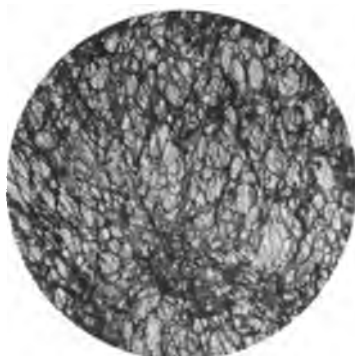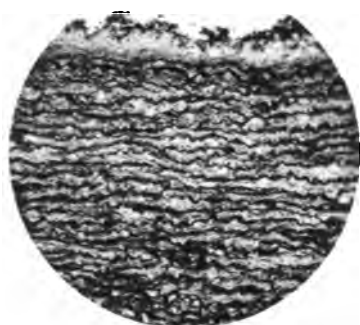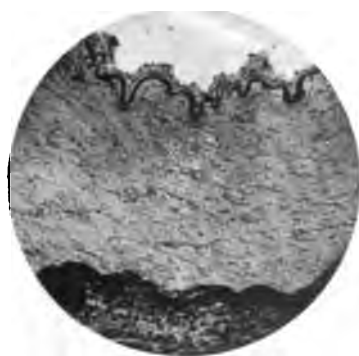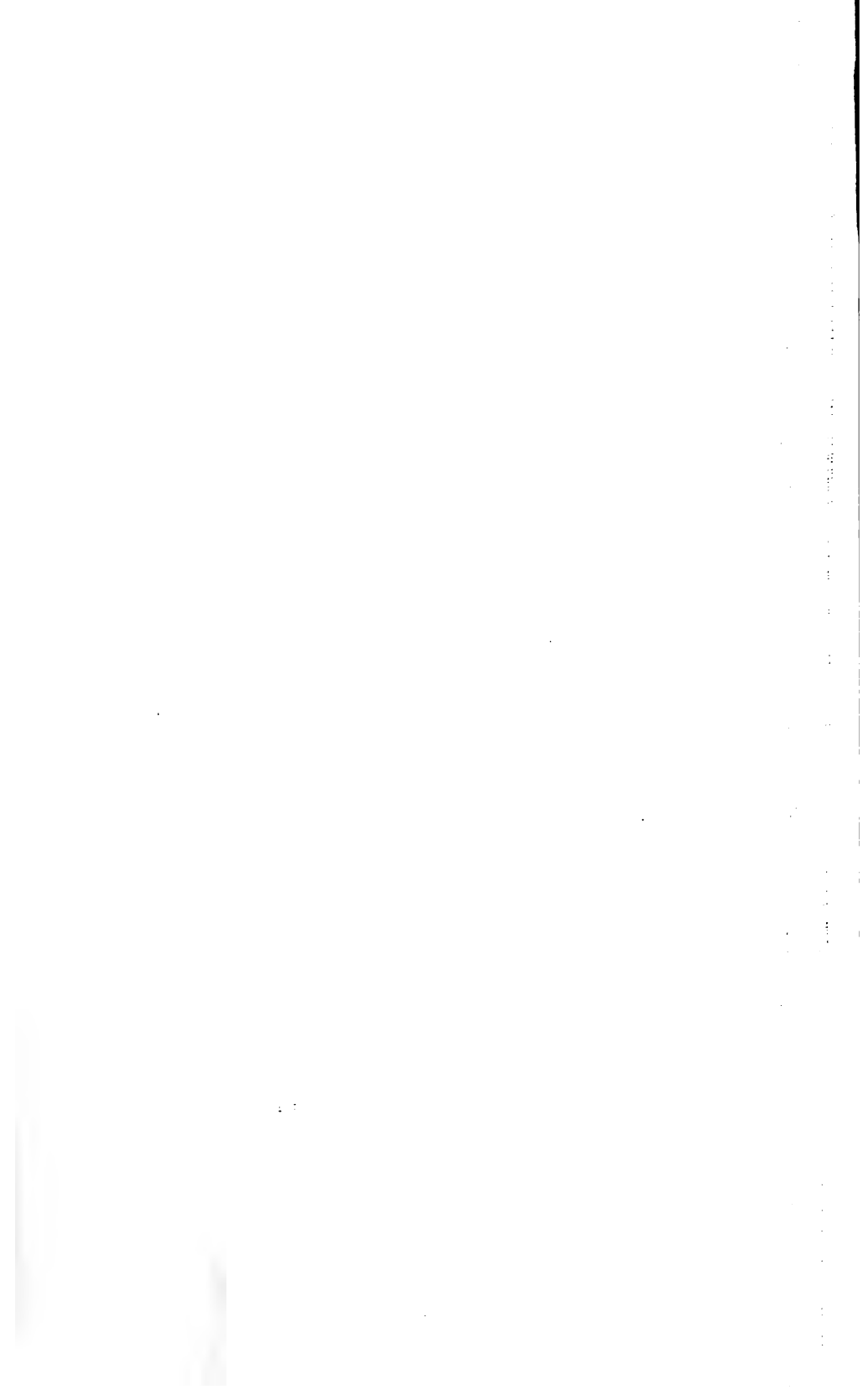
SCARLET FEVER, ITS BACTERIOLOGY, GROSS AND MINUTE
ANATOMY.   (ABSTRACT.)[1]

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The results here reported briefly are based on the exami-
nation of twenty-three cases of scarlet fever, uncomplicated
by other acute infectious diseases of childhood.   The cases
are selected from the post-mortem material of the South De-
partment of the Boston City Hospital.   The cases have been
studied in regard to their bacteriology, gross lesions, and his-
tological changes.   The work has been done in the patho-
logical laboratory of the Boston City Hospital, under the
direction of Drs. Councilman and Mallory.

I.   *Gross Pathology.* — Aside from the occasional post-
mortem evidences of the rash and desquamation the only
constant change observed was a general hyperplasia of the
lymphoid tissue everywhere.   This change was found not
only in the spleen and the large lymph nodes, but also in the
small lymph nodules of the mucous membranes of the gas-
tro-intestinal and respiratory tracts.

The spleen in most cases was large and firm, with great
increase in size of the Malpighian corpuscles.   In seven
cases, however, it was large and soft, resembling the acute
infectious spleen.

In four cases superficial necrosis of the tonsils was ob-
served.

In one case there was macroscopic evidence of miliary
necroses of the liver.

Except in three adult cases the bone-marrow was dark red,
soft, and compact.

II.   *Inflammatory Complications.* — The most common of
these were inflammation of the middle ear and broncho-pneu-
monia, each of which occurred in eight cases.

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[1] This abstract is from the complete paper published in the Medical and Surgical
Reports of the Boston City Hospital, Tenth Series, 1899.

Of the middle ears five were distinctly purulent and three mucoid. This mucoid condition of the middle ear appears to be characteristic of the early stage of the disease. In view of the fact that two of these cases died on the third day of the disease it would appear that disease of the middle ear in scarlet fever may occur much earlier than is generally supposed.

The broncho-pneumonia was of the type usually complicating the acute infectious diseases of childhood.

Infection of the antrum of Highmore was found in three of four cases examined, in two of which there was an acute empyæma on either side, and in the third a mucoid accumulation. In one of these cases there was also an inflammatory condition of the sphenoidal sinuses. In two of these cases the streptococcus was found, and in one the staphylococcus pyogenes aureus and the bacillus pyocyaneus.

The involvement of the accessory sinuses of the nose in diphtheria and scarlet fever has been but little studied, and I hope later to give a more extensive report on this condition.

Abscesses of the cervical lymph nodes were observed in four cases.

Other complications occurring in single cases were: acute endocarditis, ulceration of the œsophagus, abscess of the œsophagus, embolic abscesses of the lung and kidney, empyæma of the pleural cavities, and acute peritonitis.

III. *Bacteriology.* — In all these cases the streptococcus pyogenes was the microörganism most commonly found. In some cases it occurred alone, and in others was associated with other of the pyogenic cocci, generally the aureus, or with the pneumococcus. In five of the eight cases of broncho-pneumonia it was associated with the aureus.

In cultures from the throat and nose the streptococcus was almost invariably present. Out of eleven cases in which there was a general infection the streptococcus was found in nine. In six of these it occurred alone, and in the other three with the staphylococcus pyogenes aureus. General infection with this latter organism alone occurred in one case, and with the pneumococcus in one case. In all but two of

these cases there was some local inflammatory condition which served as an infection-atrium.

Nothing has been observed in the study of these cases that throws light on the etiology of the disease. The streptococcus can only be considered as a secondary invader.

IV. *Histology.* — The histological changes occurring in the various organs and tissues during scarlet fever, with the exception of the kidney, have received but little attention. More work has been done on the kidney alone than on all other tissues. The only extensive report is that of Klein, who in 1876 studied the cell changes in the liver, spleen, kidneys, lymph nodes, skin, tongue, and mucous membranes.

The changes in the skin of scarlet fever have been considered by the few investigators who have studied this tissue to be vasomotor.

In the cases here reported I have found a true inflammatory condition. In cases dying on the first and second days of the disease congestion of the blood-vessels and dilatation of the lymphatics are seen. On the third day, however, there is a beginning infiltration with polymorphonuclear leucocytes, and in cases dying between the fifth and eighth days this infiltration is very marked. The leucocytes can be seen in considerable numbers in the connective tissue of the papillæ, and as elongated distorted nuclei lying between the epithelial cells. In the superficial layers these are collected in large numbers, and are thrown off with the desquamating epithelium. By the twelfth and sixteenth days this condition has disappeared.

In the tongue, probably owing to the greater vascularity of this organ, the condition is much more marked. The process begins earlier, on the second day, and is at its height at about the fifth day. Everywhere polymorphonuclear leucocytes in large numbers can be seen forcing their way between the epithelial cells. In the superficial layers where the epithelial cells are dead the leucocytes are collected in enormous numbers. In some places three or four leucocytes can be seen replacing a single dead epithelial cell. The infiltration is most marked in the epithelium covering the papillæ,

a condition which explains the prominence of these bodies seen clinically. In the connective tissue of the papillæ the leucocytes are also numerous, the blood-vessels congested, and the lymphatics dilated, and contain many leucocytes. In two cases small foci of suppuration containing streptococci were found in the muscle tissue. As far as I am aware Klein is the only person who has previously described these inflammatory changes in the tongue of scarlet fever.

The same changes equally marked are found in the epithelium of the pharynx, palate, and tonsil, and in a few cases small abscesses containing streptococci are found in the lymphoid tissue of these structures.

The changes in the spleen and lymph nodes are practically identical. They consist of two cell changes; namely, the proliferation of the endothelial cells and the formation of plasma cells. The endothelial cells are derived from the cells of the reticulum, and from the endothelium of the lymph sinuses in the lymph nodes and the blood sinuses in the spleen. They are often phagocytic. This change is similar to that described by Dr. Mallory as occurring in typhoid fever, but is not so marked. In the thymus, in some cases, these endothelial cells were very numerous and exceedingly phagocytic, often containing fifteen to twenty lymphoid cells.

The plasma cells, which are derived from lymphoid cells, are found in large numbers in all parts of the spleen and lymph nodes, and sometimes in the blood-vessels. In them mitotic figures are numerous, indicating a rapid proliferation. These cells were also found in blood clot from the heart, and also in the exudate in all of the cases of broncho-pneumonia.

This process is similar to that described by Dr. Councilman as occurring in diphtheria. These changes were found not only in the larger lymph nodes, but also in the small lymph nodules of the mucous membrane of the respiratory and gastro-intestinal tracts.

An interesting condition was noticed in the veins of the spleen, namely, a collection of large numbers of lymphoid and plasma cells beneath the endothelium, separating the endothelial layer entirely from the underlying tissues. These

cells were generally arranged in irregular masses, in some cases causing irregular projections into the lumen, and in some of the smaller veins causing almost a complete obliteration. The most probable explanation of this condition is that these cells have forced their way from the circulating blood through the endothelial coat, and have been unable to penetrate the denser portion of the vessel wall.

The bone-marrow was exceedingly cellular, and, in addition to the cells usually found, large numbers of cells closely resembling plasma cells, and many of them containing mitotic figures, were seen. As I have been unable to procure the normal bone-marrow of a child for comparison I cannot draw any conclusions in regard to these cells.

In the stomach, intestine, and appendix degenerative changes were seen in the epithelium, and increase of plasma cells and eosinophilic leucocytes in the connective tissue between the glands. In the lymphoid tissues the changes were similar to those in the lymphoid tissues elsewhere. The most marked hyperplasia of the lymph nodules was seen in the stomach and the appendix.

In the myocardium fatty degeneration was found in five cases, and fragmentation of the fibres in three.

In the liver, in addition to the degenerative changes common to acute febrile diseases, irregular focal necroses were found in four cases. In three cases these foci were few in number, but in one they were very numerous. These focal lesions seem to arise in the same way as the focal lesions recently described by Dr. Mallory as occurring in the liver of typhoid fever; namely, an obstruction to the circulation, leading to necrosis, is caused by the proliferation of the capillary endothelium of the liver, or by emboli of endothelial cells from the spleen reaching the liver through the portal circulation.

In addition, in one of these four cases there were also necroses of the cells in the centres of the lobules, the so-called central necroses, probably due to a strong diffusable toxin in the circulation acting on the liver cells in the centre of the lobule, where the circulation is slowest.

In the kidney, aside from degenerative changes in nearly all cases, and embolic abscesses in one case, the only lesion found was acute interstitial nephritis, which was well marked in four cases and slight in four other cases· This form of nephritis, although it occurs frequently in scarlet fever, is not considered to be as characteristic of scarlet fever as glomerulo-nephritis. In this series of 23 cases glomerulo-nephritis, however, did not occur. This may be due to the fact that with one exception no cases were observed in which death occurred later than the sixteenth day. Glomerulo-nephritis develops generally late in convalescence. In these cases the cell foci, which Dr. Councilman has recently shown to be composed of plasma cells, were most numerous in the intermediate zone, around the glomeruli and just beneath the capsule. In some cases plasma cells were also found in the straight vessels of the pyramids. It is of interest that the cases in which an acute interstitial nephritis was present were the cases with the most marked accumulation of plasma cells in the spleen and lymphoid tissue. In these cases plasma cells were also frequently found in the circulating blood, and in the exudate in the lung. All of which facts favor Dr. Councilman's view that these cells are filtered out from the circulating blood as it passes through the kidney.

A CASE OF BONE FORMATION IN THE HUMAN BRAIN, DUE TO THE PRESENCE OF COCCIDIA OVIFORMIA. (ABSTRACT.) [1]

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The patient, a woman of forty, entered the Boston City Hospital with alcoholic neuritis, and died of pneumonia. The growth in the brain had produced no symptoms which had been noticed during life. The examination of the urine showed nothing abnormal. At the autopsy, which was made six hours after death, the left pupil was smaller than the right. The right pleural cavity was obliterated by fibrin; in spaces formed by the meshes of fibrin was clear straw-colored fluid, which showed pus cells, fibrin, and elongated diplococci. The heart muscle showed much fat. In the right lung the entire surface was covered by a fresh fibrinous exudate. The middle lobe showed an irregular area of consolidation. The other organs showed nothing abnormal, except the brain. The anterior central convolution was atrophied, and about 1.5 cm. from the median fissure there was a rough calcareous mass, the size of a small pea. This mass, upon microscopical examination, was seen to be composed of bone tissue, showing the usual hyaline matrix containing small cavities, the marrow spaces. About these marrow spaces the tissue showed rather an indistinct lamination, in which were lacunæ, from some of which canaliculi were seen to run. Outside of this layer of bone there was a band of what appeared to be osteoid tissue, containing few cells with a large amount of intracellular substance, without laminations or lacunæ. Outside of this the nodule was bounded by a layer of thickened neuroglia, and at one point, where it touched the pia, by thickened connective tissue. The marrow spaces spoken of above contained a very œdematous loose connective tissue, and in some cases

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[1] The full report of the case will appear in the Medical and Surgical Reports of the Boston City Hospital, 10th Series, 1899.

blood-vessels.   Occasionally large granular connective tissue cells were seen resembling the connective tissue cells which have taken up fat.   At one point there was a number of long spindle-shaped spaces, surrounded by connective tissue cells, and giant cells, which resembled the granulation tissue sometimes seen around fat crystals.   The bony nodule had a large central cavity, which was filled with a granular mass, apparently necrotic.   In this detritus were innumerable small oval bodies, from two to three times the diameter of a red blood corpuscle in the longer axis.   These bodies had a distinct capsule, occasionally double.   Most of them were empty, but some contained a granular mass, which at times was collected in the centre, suggesting a nucleus or spores, though no distinct spores could be made out.   The process seems to have been an acute degeneration and softening of the brain from the presence of the coccidium oviforme; followed by encapsulation; the formation of fat crystals from breaking up of the myelin and other brain structures and leucocytes; the formation of granulation tissue about this area; followed by ossification and secondary gliosis in its neighborhood.

McFarland has collected twenty cases of coccidial invasion of human organs, none of which were of the brain, and a further search of the literature failed to bring to light any case in which this had occurred, unless possibly the case of Bidder (Virch. Arch. 1882, lxxxviii, 91) be one.   In this case a small mass of bone was found in the brain, and in the centre of the bone was a granular mass containing great numbers of rounded bodies, which looked like degenerated cells, the author says, but had no nuclei.   It seems quite possible that this may have been a similar case of invasion of the brain by the coccidium.   With this case there have been found accessible twenty-two cases in all of the formation of true bone in the substance of the brain.   A study of these cases shows that the formation of bone in the brain is apparently in every case a secondary process.   In some cases ossification has taken place in a tumor of another kind.   In most cases, however, it has followed upon some inflammatory process of the brain.   As to seat, sixteen cases were in the cere-

brum, including one in the corpus callosum, five in the cere-
bellum, and one in the infundibulum.

Conclusions.

1.   The coccidium oviforme may occur in the human
brain.

2.   The grade of inflammation produced by the coccidium
oviforme, when present in the brain, is not intense, and may
run its course without noteworthy symptoms.

3.   Formation of true bone in the brain substance seems
always to be a secondary process, and occurs in other new
growths, or in connective tissue, such as forms after encepha-
litis of slight intensity.

SECONDARY INFECTION OF THE SKIN AND SUBCUTANEOUS TISSUES BY THE BACILLUS TYPHOSUS.

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If the classification of Melchior [1] be followed the post-typhoidal suppurations of the subcutaneous tissues can be divided into three groups:

(1.)   Secondary infections with the ordinary pyogenic bacteria.

(2.)   Mixed infections (bacillus typhosus and the pyogenic cocci).

(3.)   Suppurations due to the bacillus typhosus alone.

The last are rare.   One hundred and twenty-nine of Colzi's [2] one hundred and thirty cases of abscess and phlegmon were due to the ordinary pyogenic cocci.

In a careful search of the literature I have found only nine cases in which the typhoid bacillus alone was the cause of suppuration in the soft parts.   Abscesses probably due to periostitis have been excluded, and all cases in which the microörganism obtained was not sharply differentiated from the bacillus coli.

The cases can be divided into two classes:· (1) abscesses of the muscles; (2) abscesses of the subcutaneous tissues.

There are six of the former, reported by Fasching,[3] Swiezynski,[4] Tictine [5] (two cases), Daddi,[6] and Jahradnicky.[7] The abscesses appeared between the third and eighth week after the onset of typhoid fever.   Three were situated about the shoulder; two in the thigh; one in the gluteal region; and one in the pectoralis major.   In Fasching's case alone were the abscesses multiple, but in only one of these was the bacillus typhosus demonstrated.

Only three cases of subcutaneous abscess have been recorded.

Chantemesse and Widal [8] (1891) isolated the typhoid bacillus in pure culture from a large abscess of the abdominal wall fifteen months after typhoid fever.

Raymond[9] studied a similar one. The abscess formed during the relapse. At autopsy a large cavity was found anterior to the abdominal muscles. It contained two litres of pus.

Schneider[10] reports the third. Two abscesses appeared in the abdominal wall during the fever.

I am able to add another case to this series.

Case I. — P. D., male, aged 14. Admitted to the Boston City Hospital, September 27, 1898, one month after an attack of typhoid fever, with an abscess over the right olecranon. At operation four to eight c.cm. of thick pus were obtained. There was no connection with the joint or periosteum. The temperature was normal and remained so. Patient made a rapid recovery.

Bacteriological Examination. — Cover-slip preparations showed many well-preserved polymorphonuclear leucocytes ; no bacteria. A culture from the pus gave a pure abundant growth of the bacillus typhosus. The diagnosis was based upon the following characteristics: (1) It did not liquefy gelatine. (2) It was actively motile in twenty-four-hour cultures. (3) It was decolorized by Gram's method. (4) Litmus milk was rendered slightly acid, but not coagulated. A five-day culture in milk with an initial acidity of 1.5 per cent. showed an acid production in the open bulb of a fermentation tube amounting to 0.9 per cent.; in the closed branch 1.1 per cent.* (5) No gas production in 1 per cent. glucose bouillon, saccharose bouillon, or lactose bouillon. (6) It grew invisibly upon potato. (7) No production of indol in glucose-free bouillon. (8) It gave the Widal agglutination reaction with a typhoid serum, dilution 1 : 60.

Through the kindness of Dr. Pearce, who made the bacteriological examination, I am able to report a unique case of invasion of the deeper layers of the skin and subcutaneous tissue by the bacillus typhosus.

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* Dr. Theobald Smith (Journal Boston Society Medical Sciences, June, 1898) has pointed out that absence of alkali production in milk is an important characteristic of the typhoid bacillus.

Case II. — A. W., female, aged 52. Admitted to the Boston City Hospital, September 1, 1897, in the third or fourth week of typhoid fever. The blood gave a positive Widal reaction. She had several severe intestinal hæmorrhages and marked nervous symptoms. On September 13th, five days before death, a peculiar purple swelling was noticed on the inner aspect of the right lower leg. It was about 2.5 cm. in diameter and elevated nearly 1 cm. above the surface. The skin covering it was thin. It was surrounded by an area of moderate induration, red in color. It was opened with aseptic precautions and the sero-sanguinous fluid it contained carefully collected. Dr. Burrows tested this and found that it gave a positive Widal reaction.

Bacteriological Examination. — A culture from the fluid on blood serum showed a pure diffuse growth of a thick bacillus with rounded ends, varying somewhat in size; showing marked motility; no gas in sugar agar; no reaction in litmus milk; no indol production in peptone solution; positive reaction in three minutes with serum from a typhoid patient, dilution 1 : 15.

It is interesting to note that the fluid possessed agglutinative properties. As is well known, tears, sweat, and other secretions and also exudations, in which the typhoid bacillus is not present, give the Widal reaction; but it is unusual for a fluid which contains the organism to have this property. Schneider[10] obtained the bacillus from a case of hydroarthrosis, but the fluid did not give the Widal reaction, nor did the pleuritic exudate in a case reported by Menetrier.[11] Courmont's[12] studies seem to show that there is antagonism between the agglutinating substance and the typhoid bacillus, and that fluids and organs in which the bacillus is localized contain little or no agglutinating substance.

Conclusions.

(1.) Abscesses in the subcutaneous tissues and muscles are usually single.

(2.) They appear during the latter weeks of fever or

early in convalescence.   Abscesses occurring as late sequelæ probably originate in a periostitis.   (Chantemesse.)

(3.)   They run an acute course.   In this respect they contrast strongly with post-typhoid bone lesions, whose course is characterized by chronicity and a marked tendency to recurrence.

(4.)   They produce few constitutional symptoms.

(5.)   They heal rapidly after incision.

I wish to express my thanks to Dr. Councilman for permitting me to report these cases from the records of the pathological laboratory of the Boston City Hospital.

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WEIGHT OF THE "NORMAL" HEART IN ADULTS.[1]

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The importance of more exact information as to the weight of the "normal" heart was forced upon the writer's attention while pursuing an investigation of certain pathological conditions of this organ, as revealed by the autopsy records of the Boston City Hospital.

The need was first felt in the attempt to determine what cases should be classed as hypertrophied. Again, in studying the effect of a given pathological condition upon the heart the variations in weight were so great and the resultant weight was so often at variance with what might be expected from the extent of the disease as to make it plain that other factors besides the disease in question were at work in determining the heart-weight. For example, while arterio-sclerosis was found as the apparent cause of many cases of hypertrophy of the heart, cases were also found in which marked arterio-sclerosis was accompanied by a heart which was manifestly below the normal in weight.

An understanding of these other factors which affect the heart-weight was evidently desirable. It was felt that some of them at least would be acting in the case of the "normal" heart, and could be better studied there, from the very absence of those diseases which are known to have a distinct influence upon the heart-weight.

Another reason for undertaking this inquiry into the weight of the "normal" heart was suggested by a paragraph in Howard's article [2] on Heart Hypertrophy, in the Johns Hopkins Hospital Reports, to the effect that the weight of the "normal" heart differs in different localities. He says: "Observations made in Munich, the same methods being

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[1] Abstract of an article to appear in the Medical and Surgical Reports of the Boston City Hospital, 10th Series.

[2] Heart Hypertrophy. By Wm. T. Howard, Jr., M.D. Johns Hopkins Hospital Reports, Vol. III., p. 267.

used, show that the Munich heart is considerably larger than the Berlin heart.   Observations made in London give a different result from those made in Berlin.   Observers in Paris give the normal heart-weight as less than observers in either Berlin or London.   From our own observations we would conclude that the Baltimore heart weighs less than the Berlin heart, and very much less than the Munich heart." *Our* question is, what is the weight of the Boston heart?

The decision as to what hearts should be included under the head of "normal" has been to some extent an arbitrary one, especially since the systematic microscopical examination of the tissues was undertaken.   Slight pathological conditions of the heart muscle and of the kidneys are thus revealed which would not otherwise be suspected.   Where such microscopical changes have been very slight, and have accompanied an acute disease of short duration, as a pneumonia, it has seemed safe to assume that the heart-weight could not be appreciably affected.   Such cases have been included, but all doubtful cases have been excluded.

With this explanation the plan was to select only those cases in which no dilatation or hypertrophy of the heart was noted, nor any disease of the valves or myocardium, nor any special affection of the pericardium.   Cases were excluded which showed pathological conditions of the kidneys or blood-vessels.   In many cases I am convinced that no appreciable change in weight had taken place from these latter diseases, but it seemed wiser to reserve all cases with disease of the kidneys or arteries for further investigation.

No case was excluded *solely* on account of the weight. To have done so would have been begging the whole question, by assuming that we already knew the limits of weight for the "normal" heart.   The heaviest heart included in the series weighed 385 grams.   This and several others were undoubtedly slightly hypertrophied, and, on the other hand, a number at the other extremity of the table were unquestionably atrophied.   But as neither set showed pathological lesions of the heart, circulatory apparatus, or kidneys they were retained on the list and were especially valuable

in showing clearly the effect of other diseases and conditions upon the heart-weight. Later, after a study of our cases had shown adequate reasons for considering these cases abnormal, a revision of the list was made by excluding them, thus giving our revised weight of the " normal " heart a more reasonable claim for accuracy.

I have given in some detail the principles which governed the selection of cases, for I am convinced that upon the care with which this is done depends the value of the results obtained. The wide difference in the estimates of different writers as to the weight of the normal heart is partly, and perhaps chiefly, due to the different standards adopted in the selection of cases. An examination of tables made in the first half of the century shows by the frequency with which cases of kidney disease appear that the effect of such disease upon the heart was not understood, and much later we find no attention paid to arterio-sclerosis.

Thoma was the first writer to give the proper importance to arterio-sclerosis in estimating the heart-weight. His tables, published in 1882, are valuable both from the large number of cases and from the care used in their selection. They were, however, compilations from previous writers who made their observations at a time when the causes of heart-hypertrophy were imperfectly understood, and the individual observations must possess a variable value. Thoma's table may be regarded as a summary of the work done in this line up to that time. The summary of his table is included in this article both for purposes of comparison and as a check on deductions drawn from our own cases alone, which are after all rather limited in number.

Previous to May 1, 1894, the weight of the heart was not systematically recorded in "normal" cases in the Boston City Hospital autopsy records, so this became the starting point of the investigation. All autopsy reports were critically examined up to Nov. 10, 1898. All cases were taken which came within the limitations above described, provided the age was 14 years or upwards. As a result 216 cases were found which might fairly be included under the head of " normal " hearts.

Besides the weight of the heart the following data were noted as having a possible bearing upon the questions at issue : sex, age, length of body, occupation, and cause of death. The number of negroes was too small to give the question of race any value, and in the few cases which were found the weight apparently did not differ from what it would have been under the same conditions in white people. Unfortunately no data were available showing the exact weight of the whole body, so that the relation between the heart-weight and the body-weight could not be satisfactorily determined. A rough estimate was attempted, however, by making note of the condition of development and nourishment of the body whenever it was noticeably above or below the average.

The results of the investigation are shown in five tables. Table A shows the variations according to sex and age, grouped in ten-year periods. It also includes the summary of Thoma's table for purposes of comparison. It will be noted that Thoma does not separate the cases according to sex. This is not because he did not attach importance to such a division, but because such a classification was not made by some of the investigators from whom he drew his statistics.

Our table confirms the generally accepted fact that the male heart is heavier than the female. The average of our male and female cases combined would come quite near Thoma's figures in younger adult life, but would fall quite a little below his figures for the later periods. The more accurate investigation as to the existence of arterio-sclerosis in the autopsies upon which our table is based will probably account satisfactorily for this difference, which becomes noticeable just at the age when arterio-sclerosis is becoming a frequent occurrence.

Our table shows for the male heart a fairly steady increase in weight from 264 grms. for the period from 14 to 20 years up to 317 grms. for the period from 50 to 60 years. For the female heart there is a similar increase from 196 grms. for the earliest period up to 267 grms. for the period from 30 to

40 years; in the next two decades the weight falls off, reaching 246 grms. in the last.   There is no obvious explanation for this difference between the male and female heart between the ages of 40 and 60 years.   It is possible, too, that if statistics were available for a larger number of cases this peculiarity of the female heart might not be found to be a constant one.

The average weight of 134 male hearts was 290 grms., and of 82 female hearts was 253 grms.   These averages are made from all the cases, 216 in number.   Table A, however, includes only 206; two being over 60 years of age and eight not having the age given.

Table B is a summary of the cases classified according to the disease which caused death.   A general survey of the cases suggested that the duration of the disease, and the amount of wasting, were factors of great importance.   Consequently, chronic diseases accompanied by wasting were separated from other chronic diseases, and these in turn from acute diseases, making three general heads.   Further subdivision was made when the number of cases of a single disease was sufficiently large.   Thus pneumonia and typhoid fever were separated from other acute diseases, and chronic pulmonary tuberculosis from other chronic wasting diseases. Cases of sudden death, from accident, suicide, etc., were grouped under a separate heading, in the hope that they might give a better idea of the normal heart uninfluenced by disease.   The number of cases, however, is so small that deductions are unsafe.   Furthermore, some of them were far from representing the normal average of men or women. For example, the two female cases were small and poorly nourished.   They had committed suicide, and it is likely that want and privation may have played as important a rôle as disease does to reduce the heart-weight.

Leaving the group of sudden deaths out of account, as being unsafe for generalization, we find the weights for ordinary acute diseases corresponding pretty closely to the average weights of the whole series.   The shorter acute diseases have greater weights in proportion to the shortness of the

disease, while the diseases of longer duration, especially those accompanied by wasting, show a decrease in weight proportioned to the duration and the amount of wasting.   We may conclude, then, that the heart-weight varies inversely as the duration of the disease, and diminishes directly with the amount of wasting which accompanies the disease.

It seems so clearly demonstrated that the heart-weight is more or less affected by any general disease that the question arises whether we are not wrong in taking the average of these cases to represent the weight of the normal heart.   All these are cases of disease, therefore cases in which the heart-weight is more or less affected, therefore cases of more or less abnormal weight.   It would be more accurate, therefore, to call the hearts of this series " natural " hearts instead of normal hearts, meaning thereby the heart as ordinarily found under varying conditions of development and nourishment of the body in health, and under various conditions of disease which have no specific effect upon the heart.   The weight of the normal heart, properly so-called, would best be determined in cases of sudden, accidental death in perfectly healthy individuals of average development and nourishment. Such statistics I have been unable to find as yet in sufficient numbers.   A consideration of the facts shown in our table would suggest that the weight of the true normal heart would be found as high as the weight given in our table for pneumonia, if not higher, and that the effect of all diseases which do not mechanically increase the work of the heart is to diminish the heart-weight to some extent.

It is suggestive, in this connection, that Blosfeld and Dieberg, who both drew their statistics from cases of accidental death, place the normal heart-weight higher than any other writers: 346 grms. for males and respectively 310 and 340 grms. for females.   I could not get access to their writings to determine with what care the cases were selected, and whether they might fairly be called average people in good health.

Table C shows an attempt to ascertain what relation exists between the heart-weight and the body-weight.   It is only

a rough estimate, for the body-weight is not given. Those cases were selected in which the muscular development, obesity, or emaciation was considered worthy of special note at the autopsy as distinctly outside the ordinary limits. The cases are first compared with reference to the three groups of Table B, and then with the averages for the whole series. It is clearly shown that in especially heavy persons the average heart-weight is decidedly greater than it is for the average person with the same condition of disease, while in especially light persons the heart-weight is correspondingly light. While thus showing a general correspondence between the heart-weight and the body-weight our statistics do not warrant the assertion that there is a constant relation between heart-weight and body-weight, though the probability of such relation is suggested.

Some writers have said very positively that there is a definite relation between the heart-weight and the body-length. The body-length was noted in 92 of our cases. These cases failed to show any definite relation whatever between the heart-weight and the body-length. It must therefore be accepted that the body-length is not in itself a safe guide to the heart-weight, or else it must be assumed that these 92 cases represented very exceptional conditions. It was found not only that a steady increase in length of body was not accompanied by a corresponding increase in heart-weight, but that there were very wide variations in weight for any given height. For example, ten males with a body-length between 175 and 180 cm. had hearts varying in weight from 180 to 365 grms. In other words, the heaviest heart weighed a little more than twice as much as the lightest for the same length of body.

Table D classifies the cases according to occupation. Only the male cases were thus classified, the occupation of the females being monotonously stated as " housework," without indicating the amount of labor involved. The following cases were excluded: 17 cases in which the occupation was not stated and 4 soldiers recently returned from Cuba, where great emaciation and a very light heart-weight clearly indi-

cated exceptional conditions. This leaves 113 of the 134 males to be classified by occupation.

First those cases were selected which had an extra laborious occupation. The average weight in these 12 cases was 334 grms., considerably above the average of 290 grms. Next the general class of laborers was taken, with an average of 296 grms., only slightly above the general average. Teamsters and coachmen formed the only other group, with a large enough number to have the occupation considered separately. Their average was 298 grms., about the same as laborers. The other cases were divided into two groups, those with an indoor and sedentary occupation and those whose occupation involved an " average," but not very great, amount of labor. The table shows a gradual increase in the average heart-weight for these various groups, corresponding to the amount of labor involved, thus showing a definite relation between the heart-weight and the amount of labor involved in the occupation.

An excessive and constant use of alcohol was noted in 16 males and 4 females. These cases give an average heart-weight of 313 grms. for the males and 285 grms. for the females. While these averages are about 25 grms. higher than the general average for either sex the number of cases is so small as to make one hesitate to draw any definite conclusions. We ought to exclude 5 of the male cases on account of extra laborious occupation, leaving 11 cases, with an average of 309 grms. The evidence, as far as it goes, is in line with the statement frequently made that the constant use of alcohol increases the heart-weight, though individual cases were found where this did not seem to be true.

It has thus been demonstrated that a number of factors are at work to influence the weight of the heart, and it is shown that the heart is affected by comparatively slight influences, provided they are persistent. Having determined what these influences were, it was then possible to exclude certain cases as abnormal. In this way a revised average was obtained, and it was demonstrated that practically all cases beyond certain limits were abnormal. A further help

in determining the limits of the variations in the weight of
the " natural " heart is furnished by Table E, where the num-
ber of cases for a given weight is given.

By these means we have arrived at the following conclu-
sions in regard to the weight of the " natural " heart:

The average weight for males is 290 grms.

The average weight for females is 260 grms.

The normal variations are, for males from 250 to 325
grms., and for females from 225 to 300 grms.

Weights for 25 grms. outside these limits *may* be " nor-
mal; " beyond that they are almost certainly abnormal.

TABLE A.

PERIOD.	THOMA'S TABLE.		MALES.		FEMALES.	
Years.	No. of Cases.	Average Weight in grms.	No. of Cases.	Average Weight in grms.	No. of Cases.	Average Weight in grms.
15–20	51	233.7	12	264	7	196
20–30	164	270.6	41	277	25	251
30–40	300	302.9	33	297	19	267
40–50	243	303.	31	297	21	256
50–60	225	316.6	9	317	8	246

Average : 134 males = 290 grms.
82 females = 253 grms.

TABLE B.

SEX.	Pneu-monia.		Sudden.		Typhoid Fever.		Other Acute.		Chronic.		Chr. Pulm. Tubercu-losis.		Chronic c. Wasting.	
	no.	wt.	no.	wt.	no.	wt.	no.	wt.	no.	wt.	no.	wt.	no.	wt.
Males..	28	313	8	296	22	285	43	287	11	284	13	281	9	251
Females	13	289	2	220	10	271	29	253	6	258	14	227	8	221

Summary.

Sex.	Total Average.		Total Acute.		Chronic.		Total Wasting.	
	no.	wt.	no.	wt.	no.	wt.	no.	wt.
Males	134	290	101	295	11	284	22	269
Females	82	253	54	264	6	258	22	225

TABLE C.

Disease.	Sex.	Total.		Muscular and Obese.		Emaciated.	
		no.	wt.	no.	wt.	no.	wt.
Acute......	Males	101	295	11	337	13	256
	Females	54	264	7	320	4	240
Chronic	Males	11	284	3	333	1	235
	Females	6	258	...	...	1	210
Wasting....	Males	22	269	1	325	15	249
	Females	22	227	...	...	12	210
Total	Males	134	290	15	335	29	251
	Females	82	253	7	320	16	217

TABLE D.

Occupation of Males.

	Cases.	Grams.
Indoor occupations.............................	26	272
Average occupations	46	284
Laborers	20	296
Teamsters and coachman...........	9	298
Extra heavy occupations	12	334
Total.......................................	113	Average, 290

TABLE E.

WEIGHT IN GRAMS.	150 to 200.	200 to 225.	225 to 250.	250 to 275.	275 to 300.	300 to 325.	325 to 350.	350 or over.
Males......................	4	7	12	20	30	28	19	14
Females....................	10	15	16	12	11	14	2	2

Revised average weight : Males = 290 grams.
Females = 260 grams.

A STUDY OF THE ENCAPSULATED BACILLI.

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The classification and identification of the capsule-forming bacilli have for a long time given rise to much discussion and difference of opinion, while the recognition of their importance has steadily increased.

These bacilli are to be regarded as among the pus organisms, producing a great variety of inflammations in many of the organs and tissues.   Cases of pneumonia, pyelonephritis, abscesses of the kidney, cystitis, otitis media, and other suppurative processes have been reported as due to these organisms. In many of these cases the bacillus has been described as a new capsule bacillus differing in some slight detail from those already described.

The best known of these are the bacillus pneumoniæ of Friedländer, the bacillus capsulatus mucosus of Wright and Mallory, and the bacillus capsulatus Pfeiffer.   In addition to these there are several others which are regarded as specific in certain morbid processes, and as often occurring without lesions on the mucous membrane of the nose and throat. These are described as bacillus ozænæ, bacillus capsulatus mucosus or bacillus sputigenus crassus, and bacillus rhinoscleroma.

The *bacillus Friedländer* may be taken as the type organism of this class, as it is best known, and was the first to be described.   Its characteristics as given in the general works on bacteriology are as follows: It is a short, thick rod with rounded ends, sometimes growing out into long filaments.   It forms moist, colorless, mucoid colonies on gelatine plates without liquefaction.   It is non-motile, grows best at 37° C., but will grow at room temperature.   It is aerobic, and facultatively anærobic; it does not produce spores and does not coagulate milk.   There is only slight clouding of peptone solution, without any indol reaction.   With Gram's stain the bacillus de-

colorizes but slowly, and in tissue-staining sometimes only partially, leaving beaded chromophilic granules, which may be seen within the capsule if a counter-stain is used.

Its pathogenesis, its production of gas and of acid, and its capsule formation have all been differently stated by different observers. These four important characteristics are indeed subject to a good deal of variation, and it is not an unreasonable assumption to suppose that this variability accounts for the description of new capsule bacilli which are in reality only accidental variations of those already known. A comparative study of these points for all the bacilli under consideration will be made later in this paper.

When we compare this description of Friedländer's bacillus with the characteristics of the other capsule bacilli, as given by the standard authorities, we find the points available for a differential diagnosis slight and not absolute. The following descriptions are taken for the most part from Flügge, with comparisons from Günther, Lehmann and Neumann, and Sternberg:

Bacillus ozænæ (*B. capsulatus mucosus Fasching*) is separated from the bacillus Friedländer by the mucoid appearance of the colonies. It is said to be occasionally encapsulated in artificial media, and to be very pathogenic for mice and guinea-pigs. Considerable variation has been reported in its gas and acid production, and in the coagulation of milk, which latter is generally said to be absent.

Bacillus rhinoscleroma is morphologically and culturally similar to bacillus ozænæ. Virulence variable, gas formation variable. Some observers have claimed to be able to fix the organism in tissues so that it will not decolorize by Gram. No special feature is given which would distinguish it from bacillus ozænæ.

Bacillus capsulatus septicus. Proteus hominis capsulatus. — Very similar to bacillus Friedländer; differentiated from it by a tendency to form long threads; young cultures have very short rods. Virulence variable. Said to stain by Gram in the tissues, but certainly the short forms do not stain by Gram.

Bacillus Pfeiffer. — Very similar to bacillus Friedländer;
no distinguishing characteristic given.

To this list of the more common of the capsule bacilli we
may add, for the sake of comparison, *bacillus lactis aerogenes
Escherich*, which resembles bacillus Friedländer on the one
hand and bacillus coli communis on the other. Occasionally
this bacillus has been reported to have capsules. It forms
gas rapidly and abundantly, is practically non-pathogenic,
or pathogenic only in overwhelming doses, and is distin-
guished from bacillus Friedländer by its coagulation of
milk, but this characteristic is said to be variable.

As these descriptions show, a classification of bacteria
upon morphological peculiarities is often unsatisfactory, as
individuals may vary or varieties resemble each other closely.
But if we can augment and strengthen a morphological classi-
fication by chemical tests based upon any of the vegetative
phenomena of the bacteria we shall arrive at a surer and
more scientific means of distinguishing between similar organ-
isms. With this in view the fermentative activity of these
bacilli has been studied as it is shown in gas and acid pro-
duction and in coagulation of milk. The media used have
been 1 and 2 per cent. solutions of glucose, saccharose, and
lactose, in bouillon which has previously been rendered free
from all trace of muscle sugar by the fermentation process
described by Theobald Smith. This is as follows: 500
grammes of lean meat are soaked overnight in one litre of
water, either in the cold or at 60° C. The extract is inocu-
lated with a rich fluid-culture of some acid-producing bac-
terium, as colon bacillus, and is allowed to ferment for 10
hours at 37° C. Peptone and sodium chloride are then
added in the usual proportions, and the solution is boiled,
filtered, neutralized, and sterilized. Neutralization is tested
by titration of phenolphthaleine against a $\frac{1}{20}$ normal potassic
hydrate solution, and the same solutions are later used in
testing the acid formed.

A single fermentation tube filled with this sugar-free
bouillon is then inoculated with colon bacillus to make sure
that all trace of muscle sugar has disappeared, and if no gas is

produced in this the remainder is divided into three portions, to which 1 per cent. respectively of glucose, saccharose, and lactose are added.

The fermentation tubes into which these three sugar solutions are then run are of several patterns, which vary somewhat in capacity. As the quantity of gas produced depends upon the amount of sugar present, and this again depends upon the amount of bouillon in the closed arm of the tube, we measure the quantity of gas in terms of the amount of bouillon in the closed arm. But when a long series of observations is made with the same tubes it is unnecessary to reduce all the figures to such fractions, as the tubes of one pattern are very uniform in capacity, and it is only necessary to measure the column of gas in centimetres.

The production of gas is to be noted at the end of every twenty-four hours, and the tubes allowed to stand a day or two after gas has ceased to be produced, as there is always a slight shrinkage. The gas is next tested for the proportion its hydrogen bears to its carbon dioxide. The carbon dioxide is absorbed by the addition of an alkaline hydrate, and the remaining gas is identified as hydrogen by ignition.

To accomplish this the bulb of the fermentation tube is completely filled with 2 per cent. sodium hydrate and the thumb is then pressed firmly against the opening. By tipping the tube the gas is thoroughly mixed with the fluid, and finally allowed to return to the top of the closed arm. A suction will be felt against the thumb pressed over the opening, and on removing the thumb the column of fluid will rise in the closed arm to take the place of the carbon dioxide which has been absorbed.

After measuring the remaining gas the cotton stopper is replaced in the opening, the gas is returned to the bulb of the tube, and on removing the stopper and applying a lighted match the gas will explode with a blue flame, characteristic of hydrogen.

The bacilli used in this study have been the following:

1 & 2. Two cultures of bacillus pneumoniæ Friedländer, obtained from two autopsies at the Boston City Hospital.

3.   A culture of bacillus Friedländer from Göttingen Institute of Hygiene.

4.   A culture of bacillus Friedländer from Kral's Laboratory, Prag.

5.   A culture of bacillus Wright and Mallory.   Western Reserv., Ohio.

6.   A culture of bacillus Pfeiffer.   Johns Hopkins, Baltimore.

7.   A culture of bacillus Pfeiffer.   Kral's Laboratory.

8.   A culture of bacillus ozænæ.   "   "

9.   A culture of bacillus rhinoscleroma. "   "

10.   A culture of bacillus capsulatus septicus.   Kral's Laboratory.

11.   A culture of bacillus lactis ærogenes.   Kral's Laboratory.

12.   A culture of bacillus sputigenus crassus.   Göttingen Hygienic Institute.

13.   A culture of bacillus rhinoscleroma.   Göttingen Hygienic Institute.

The most characteristic feature of this entire group of organisms, and that which has given rise to the name "mucosus," is the production of a translucent mucoid substance which makes up a considerable part of the inflammatory exudate caused by it and of the growth upon artificial media.

In young colonies this is colorless, but after a few days it becomes milky white and may form a thick mass at the bottom of slant cultures.   This substance can often be drawn out into threads, and is undoubtedly the basis of the capsule formation.

The question of capsule formation is not a simple one, nor is it completely solved as yet.   The ease with which artifacts may occur and be mistaken for capsules is to be considered, and the invariable standard followed of not speaking of a bacillus as encapsulated unless it has a sharply circumscribed and not a hazy corona.   But the very method of formation of these mucoid envelopes makes transition forms between true capsules and mucoid halos without definite

membranes.   According to Fischer, the gelatinous substance
is formed from the outer layers of the cell-membrane, which
take up water and are partially dissolved.   They are replaced
by the active growth of the inner layers.   The nature of the
nutritive material has an influence on this gelatinous forma-
tion.

The definite capsule formation, therefore, appears to be a
variable and inconstant characteristic, although the produc-
tion of a mucoid or gelatinous extracellular substance, with a
consequent tendency to capsule formation, is very constant
and striking, both in tissues and in cultures.   Capsules with
definite membranes occur only in tissues and exudates.
Pseudo-capsules are often seen in artificial cultures.

For the study of capsule formation the stain recently pub-
lished by Kaufmann, in the Berlin Hygiene Review, is of
great service.   The simplified method in which I have used
this stain for smears of exudates and of cultures is as follows:

1. Stain with Lœffler's alkaline methylene blue, heating
for a few seconds until steam rises.

2. Wash in water made alkaline by a few drops of con-
centrated potassic hydrate.

3. Dry.

4. Treat with 1% solution of silver nitrate for two minutes.

5. Wash as in (2).

6. Stain for thirty seconds with fuchsine.   (1 part satu-
rated alcoholic fuchsine to 20 parts water.)

7. Wash as in (2).   Dry.   Mount.

The bacilli should be intensely blue-black and the capsules
red.

The stain is also of service for bacilli in tissues and for the
pneumococcus.

In this characteristic of mucoid production we are able to
separate the organisms under consideration into two classes:
Bacilli Friedländer, ozænæ, sputigenus crassus, rhinoscle-
roma, and Wright and Mallory produce a colorless sub-
stance in young colonies, becoming whitish after the lapse
of from two to four days.   Bacillus capsulatus Pfeiffer,
Kruse, and ærogenes, on the other hand, are whitish from

the first, and the colonies are flatter, moister, and more nearly resemble those of the bacillus coli communis. Again, the capsules of the first class are more distinct and easily stained, while with the latter three the ordinary staining methods often fail to show capsules in exudates, and, even with Kaufmann's stain, bacillus ærogenes can only be said to have pseudo-capsules and not a definite membrane. There is also no simulation of capsule formation on artificial media for these three.

The pathogenic power of these bacilli is hard to estimate from the cultures available for their study, on account of the varying lengths of time since their isolation from the tissues. For the most part attempts at increasing their virulence by passage through mice or very young guinea-pigs failed, and even very large (5 c.cm.) intraperitoneal injections of bouillon cultures into small guinea-pigs failed to kill. The experiment of growing the cultures on agar slants smeared with fresh blood, as has been done with the pneumococcus, was not tried. A culture of Friedländer's bacillus, freshly recovered from an animal tissue, will kill a guinea-pig of from 300 to 400 grammes in from 18 to 24 hours, in doses of 1 c.cm., intraperitoneally. Cultures grown for a long time on artificial media are not pathogenic in the ordinary doses. Conforming to bacillus Friedländer in these respects are bacillus sputigenus crassus and bacillus Wright and Mallory.

Pfeiffer's bacillus appears to be more regularly pathogenic for guinea-pigs. Bacillus ærogenes, in doses of 5 c.cm., proved fatal for a small guinea-pig in 18 hours, while bacilli rhinoscleroma, ozænæ, and Kruse were regularly non-pathogenic. No distinction can therefore be made between these bacilli in point of pathogenesis, but as a group they have a low degree of this power.

We come now to the gas production. The experiments made with bacillus Friedländer in this regard show that when it is recovered fresh from an autopsy or an inoculated animal it produces gas in a characteristic way which enables it to be distinguished from organisms of a different type, but that in old cultures on artificial media the gas production is quite

variable and uncertain. In fresh cultures grown upon 1 per cent. glucose, saccharose, and lactose bouillons respectively the production of gas is most abundant on saccharose, next on glucose, while there is only a small quantity or none at all on lactose. These proportions are quite constant. The total quantities, however, vary, but in general terms there is half as much gas as there was originally bouillon in the closed arm for saccharose; between ¼ and ⅓ for glucose; and less than ⅙ for lactose. The proportions of the hydrogen to the carbon dioxide are harder to estimate, and the margin of error is greater, from the greater difficulty in measuring, and from the possibility that not all of the carbon dioxide is absorbed, so that the significance of the results is not to be regarded as of as much value as the proportions already given.

Still the proportion of the hydrogen to carbon dioxide may be stated as approximately 1.5 to 1 for saccharose, and generally a somewhat higher proportion of hydrogen for glucose. The small quantity of gas formed with lactose did not permit an estimation of its composition. These figures show considerable variation in a long series of experiments, and little reliance can be placed upon them. Larger percentages of sugar give a greater total quantity of gas in a proportionately greater length of time. One per cent. sugars are practically all consumed within 48 hours. While glucose bouillon offers the richest and most unvarying food for bacterial growth in general, it is the least valuable of the sugars for determining the differences in gas formation, as all organisms act more nearly alike on it. Comparing these results with the gas production of the other bacilli, we find that they again fall into the same two classes noted in the mucoid and capsule formation.

Taking bacillus Pfeiffer as the type of the second class, the production of gas is in the first place more abundant on all three of the media; and secondly, lactose furnishes a good food for growth and gas formation. The proportions between the three sugars are more nearly equal, so that it is hard to say if there is any absolute superiority of one over the other. Still saccharose usually produces slightly more gas than lac-

tose, while glucose is the poorest of the three.   Again, the gas production is as abundant on old as on freshly isolated cultures.

Bacillus ærogenes conforms to these rules in general, producing as much gas on lactose as on saccharose or glucose, and as much on old as on fresh cultures.   But occasionally there is only slight or no gas production on saccharose, and in this respect it differs from Pfeiffer's bacillus.

Bacillus Kruse follows the general rules of these two, producing about equal proportions on all three sugars, but, as was noted earlier, the culture used is apparently greatly attenuated in virulence from long growth on artificial media; and this is borne out in the gas formation, for the total quantities are not as large as those of Pfeiffer and ærogenes.

This same difficulty is met with in the bacilli belonging to the first class.   Where they are recovered fresh they produce gas in the way characteristic of Friedländer's bacillus, but where they fail in pathogenesis the production of gas is inconstant and uncertain.   But this very characteristic of old cultures has already been noted as occurring in Friedländer's bacillus, so that their similarity to it is strengthened thereby.

Bacillus sputigenus crassus, and Wright and Mallory, show no variation from Friedländer's bacillus in gas production.

Bacillus ozænæ has the right proportions for the three sugars, but the total quantities are low.

Bacillus rhinoscleroma, however, presents a difficulty. Two cultures of this were studied, one from Göttingen, originally obtained from Berlin, the other from Prag.   The first, though non-pathogenic, produced gas in a way fairly characteristic of Friedländer; the second inoculated in a large dose into a small pig proved fatal in 18 hours.   The peritoneal exudate contained many bacilli with good capsules, but no gas was formed on any of the sugars.   The glucose tube was thickly clouded, the saccharose was clouded throughout the bulb, but not in the closed arm, while the lactose had only a film on the surface exposed to the air in the bulb.

One culture therefore corresponds to Freidländer; the other may originally have had the same characteristics and have

lost them through long growth on artificial media. But we cannot draw definite conclusions without a further comparison with freshly isolated cultures. These observations, however, may prove of service in any future study of the bacillus rhinoscleroma.

No positive conclusions can be drawn in regard to the proportion of hydrogen to carbon dioxide for these two groups; there is no appreciable difference between them, and the only result of the many tests was to show that unless some special and accurate apparatus can be devised for the measurement of these two gases the test will be of no value in studying and classifying bacteria.

The results in the study of acid production show that bacillus Friedländer is an abundant acid producer; the extent of its activity in this regard is dependent upon the amount of sugar present in the medium used, and also in that the production of acid beyond a certain point will stop the further growth of the bacilli. This is always true for glucose bouillon, the form most commonly used, but for the other sugars the production of acid varies according as the sugar is or is not a good food for the growth of this organism. When there is no perceptible clouding of the bouillon, as sometimes occurs with lactose, there is also no formation of acid. When the bouillon is thickly clouded, but without gas formation, as sometimes occurs in old cultures, it might be supposed that there must be strong acid formation, which had checked further growth and gas formation. This is not the case, however, as there is often no more acid than in a tube in which there has been good gas formation. The virulence of the culture appears to have little effect upon the acid formation.

In this quality of acid production we find no characteristic feature which enables us to separate the bacilli into classes, excepting that, as already mentioned, when bacillus Friedländer and those of its group fail to grow well on lactose bouillon they produce no acid, while the second group produces as much acid as on glucose or saccharose.

The quantity of acid production for Friedländer is such

that 1 c.cm. of a 2 to 3 days' old glucose-bouillon culture is neutralized by $\frac{1}{30}$ c.cm. normal sodium hydrate solution. This amount does not alter appreciably for saccharose or for the other bacilli, except when there is no growth, as for Friedländer on lactose and for ærogenes on saccharose.

In the coagulation of milk the two classes are well defined, ærogenes coagulating in one day and Pfeiffer and Kruse on the second, while there is no coagulation for the Friedländer group. An exception, however, must be made for the atypical culture of rhinoscleroma from Prag, which coagulated milk in three days, while the Berlin culture showed slight coagulation on the fourth day.

General Conclusions.

1. We find in the gas production of these bacilli a valuable aid for their study and identification.

2. The proportions of hydrogen to carbon dioxide do not offer any additional evidence.

3. The acid formation supplements the evidence afforded by the gas production.

4. The results of the study of all the characteristics of these bacilli enable us to divide them into two types, which may be called the Friedländer group and the ærogenes group :

Friedländer's group comprises bacillus pneumonæ Friedländer, bacillus ozænæ Fasching, bacillus capsulatus mucosus or bacillus sputigenus crassus, bacillus Wright and Mallory, and possibly bacillus rhinoscleroma. Its characteristics are bacilli forming primary colorless colonies becoming whitish when old; easily stained capsules which occur only in tissues and exudates; pseudocapsules occasionally in artificial media; gas production most abundant on saccharose; slightly less on glucose, but little or none on lactose; no, or slight, acid formation on lactose; and no coagulation of milk. The ærogenes group, which probably has more members than the three studied, is characterized by primarily whitish colonies; capsules difficult to stain and inconstant in

occurrence; no pseudocapsules in artificial media; more abundant and constant gas formation on all three media; rapid coagulation of milk; and equal amounts of acid formation on all three sugars.

These results strongly suggest that there are in reality only two primary distinct organisms, bacillus Friedländer and bacillus ærogenes, and that the differences noted in the different cultures are accounted for by the well-recognized tendency of these bacilli to vary within certain limits. We cannot, however, make a positive conclusion in this matter until more cultures have been observed.

BACILLUS.	Total gas, stated in centimetres.			Proportion of hydrogen to carbonic dioxide.			Acid: amount of normal NaOH required to neutralize 1 c.cm. bouillon culture in c.cm.		
	Glucose.	Sacch.	Lactose.	Glucose.	Sacch.	Lactose.	Glucose.	Sacch.	Lactose.
Friedländer .... {	$5.8 = \frac{1}{2}\%$	$7.8 = \frac{1}{3} - \frac{1}{2}\%$	} 0	$\frac{1}{1}$	$\frac{1.5}{1}$	$\frac{0}{0}$	$\frac{1}{30}$	$\frac{1}{20}$	0
Mucosus caps. sput.	4.5	5.2	0	$\frac{3.5}{1}$	$\frac{2.5}{1}$	$\frac{0}{0}$	$\frac{1}{40}$		0
Ozænæ	4.	.8	0	$\frac{3}{1}$	$\frac{2.3}{1}$	$\frac{0}{0}$	$\frac{1}{33}$	$\frac{1}{30}$	0
Wright & Mallory.	3.8	7.	0		$\frac{1.5}{1}$				
Rhinoscleroma ...	6.5	2.5	0	$\frac{2.3}{1}$	$\frac{2.1}{1}$	$\frac{0}{0}$	$\frac{1}{33}$	$\frac{1}{20}$	0
Pfeiffer	6.8	9.	7.8	$\frac{1.4}{1}$	$\frac{2}{1}$	$\frac{3}{1}$	$\frac{1}{70}$	$\frac{1}{20}$	$\frac{1}{20}$
Kruse	2.8	1.8	3.3				$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{40}$
Ærogenes	5.	4.8	6.5	$\frac{3}{1}$	$\frac{3.8}{1}$	$\frac{5.5}{1}$	$\frac{1}{33}$	$\frac{1}{40}$	$\frac{1}{40}$
Friedländer observations of Theobald Smith	$\frac{1}{3} - \frac{1}{2}\%$	$\frac{1}{3} - \frac{1}{2}\%$	up to $\frac{1}{5}\%$	$\frac{1.4}{1}$	$\frac{1.3}{1}$				
Colon	$\frac{1}{3} - \frac{1}{2}\%$	Variable		$\frac{1}{2}\%$ $\frac{2}{1}$					

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on March 21, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

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CONTENTS.

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BLOOD CULTURES IN SEPTICEMIA, PNEUMONIA, MENINGITIS, AND CHRONIC DISEASE.[1]

FRANKLIN W. WHITE, M.D.

(From the Pathological Laboratory of the Massachusetts General Hospital.)

The value and significance of bacteriological examination of the blood are so evident that many observations have been made in the last twenty years in an endeavor to throw light on the etiology and course of infectious disease. The object of such investigation is not wholly theoretical, to explain the course of disease, but practical, as a means of diagnosis and prognosis. The results obtained have been varied and contradictory, which is probably due in part to faulty methods of observations in use. The old method of pricking the finger and using a few drops of blood for culture has the disadvantage that too small an amount of blood is used to find the bacteria if they are few in number, and involves great danger of contaminating the cultures with bacteria from the skin. The later method of aspiration of a superficial vein by canula or sterile syringe has the advantage of furnishing a satisfactory amount of blood for examination, and limiting the dangers of contamination.

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[1] To be reported in full in the Journal of Experimental Medicine, vol. iv. 1899.

Until recently post-mortem findings have been considered of equal significance with intra-vital ones, but there is no question that cultures during life in spite of incompleteness of methods furnish a better indication of general blood invasion during disease than autopsy reports, as the latter do not exclude agonal and post-mortem invasions.

Our observations extend over a series of ninety-two cases, consisting of eighteen cases of severe sepsis, nineteen cases of lobar and lobular pneumonia due to the pneumococcus, eight cases of epidemic cerebro-spinal meningitis, thirty-seven cases of severe chronic diseases, also ten miscellaneous fatal cases. Cultures were made during life, usually in the late stages of disease, and in many of the cases as soon as possible after death (one half-hour after).

The cultures in cases of septicemia, pneumonia, and meningitis were made in order to find out if possible how frequently, in addition to toxine absorption, the blood was invaded by the specific organism of the disease, also the time of occurrence of such general invasion, and its relation to mortality.

In the cases of chronic disease the cultures were made both before and after death, to determine the frequency of general blood invasion in the late stages of disease and during the last few hours of life, the so-called " terminal infections " and " agonal infections."

Blood was obtained during life by aspiration of a superficial arm vein with a glass syringe, under aseptic precautions. The aspiration was rendered practically painless by the use of an ethyl chloride spray. Blood was obtained after death by aspiration of the heart. The needle was thrust into the heart through the fourth intercostal space close to the sternum, and as it has to pass through the pericardial and probably the pleural cavity on its way to the heart post-mortem blood was used only in cases where these cavities were not infected. Five c.c. of blood were aspirated in each case, and one-half c.c. mixed with each of two bouillon and eight agar tubes; four of the agar tubes were slanted, and four plated. The cultures were grown and examined in the usual way.

I. Septicemia, Pneumonia, and Meningitis.

The eighteen cases of sepsis (namely, purulent appen-
dicitis, general peritonitis, osteomyelitis, phlegmon, erysipe-
las, empyema, etc.) were all fatal.   They consist chiefly of
severe local septic infections without formation of metastatic
abscesses; only one case can be characterized as pyemic.
In the eighteen cases, most of which were examined more
than once, specific bacteria were found in the blood during
life only four times, the streptococcus pyogenes in pure
culture three times, and the staphylococcus pyog. aureus in
pure culture once.   In each case the species of bacteria causing
the initial lesion produced also the general invasion; no het-
erologous organisms were found.   In the two positive cases
in which an autopsy was performed the same bacteria found
in the blood during life were found distributed through the
organs at autopsy.   In six of our fourteen negative cases an
autopsy was performed; no evidence of a general infection
was found in any of them.

The number of bacteria found per c.c. during life was never
large (comparatively speaking), at most fifty to sixty strep-
tococci per c.c.   In two cases there was a great increase in
the number of bacteria found immediately after death over
the number found two days before.   This may be interpreted
as a growth of bacteria in the blood or an increased number
entering it.

The time of blood invasion was late in the disease : cultures
from the fifth to tenth day in three cases were negative; later
cultures were positive in each instance.

Our nineteen cases of pneumonia were all at least mod-
erately severe and ten were fatal.   In three cases, all fatal, the
pneumococcus was obtained from the blood during life.   Two
positive cases were autopsied and a general pneumococcus
infection found.   Eight negative cases were autopsied and
none showed any evidence of general infection.   The num-
ber of bacteria found was from ten to sixty per c.c.   No
organism save the pneumococcus was found in the blood in
any case.   The time of general infection was always late in the

disease, negative results being obtained three to five days before death and positive results one to two days before death.

Our eight cases of cerebro-spinal meningitis were all severe and six of them fatal. No pathogenic bacteria were found in the blood cultures either before or after death. The abdominal and thoracic viscera were found sterile in three out of four autopsies. In the fourth case putrefactive bacteria were present.

In reviewing our cases with reference to frequency of invasion it is seen that our results in septicemia are in accord with those of recent observers, such as Neuman, Kraus, and Kühnau ; we have not obtained the frequent positive results of the earlier men. Our series of fatal septic affections proved to be for the most part cases of blood intoxication, with resorption of toxines produced by bacteria growing in a local primary focus, and only in a small proportion of cases did the organisms enter the general circulation. The frequency of general invasion in our pneumonias is like that in the cases of Kohn, Kühnau, and Kraus.

No conclusion can be drawn from our septic cases about the relation of general infection to mortality, save that a large per cent. may die without general infection. All our positive cases of pneumonia died, while nine negative cases recovered and eight negative cases died, or, to put it in another way, a general invasion was found in less than one-fourth of the fatal cases.

We believe that the value of blood cultures as a means of diagnosis in obscure cases of so-called " cryptogenetic sepsis " has been overestimated. Positive results during life are always interesting and valuable, and are removed from the suspicion of agonal or post-mortem invasion which sometimes obscures autopsy findings, but it is evident from the large per cent. of negative results, even in the severest type of cases, that the search for the causes of disease by this method will often prove futile. In regard to prognosis it is evident that a negative culture does not give much assistance, while a positive result gives a very unfavorable prognosis in the majority of cases.

In our patients the time of general infection in both septi-
cemia and pneumonia has been late in the disease, only a
few days before death.   This has been the experience of
Canon, Czerniewski, and Kühnau in cases of septicemia, and
of Kohn in cases of pneumonia.

We have never noted any marked change in the clinical
course of these cases coincident with the occurrence of a
general infection.

II.   Chronic Diseases.

Osler and Flexner have called attention to the fact that
local infectious processes are of frequent occurrence in pa-
tients afflicted with chronic disease, and it is known that gen-
eral infection occasionally occurs as a cause of death.

In addition to this, evidence from various sources has accu-
mulated indicating that more or less frequently, during the
last few hours of life, bacteria which are present in certain
organs, especially the bowel, succeed in overcoming the
weakened resistance of the individual, get into the blood
stream, and are generally distributed over the body.   This
process, which is termed " agonal invasion," naturally has no
influence on the course of disease in the individual, but has a
very important bearing on the value of bacteriological find-
ings at autopsy.   If an agonal invasion of bacteria is a
frequent occurrence it is very evident that the bacterial con-
tents of organs at autopsy often do not represent the condi-
tions present during life, and that our conclusions as to the
causes of disease from post-mortem findings must be much
restricted.

Our object has been to determine the frequency of these
so-called terminal and agonal infections.   Our observations
cover thirty-seven cases of severe chronic disease (cancer,
sarcoma, cardiac and arterial disease, nephritis, tuberculosis,
pernicious anemia, gastric ulcer, etc.), of which thirty died
in the hospital, and nineteen were autopsied; also ten mis-
cellaneous fatal cases, five of which were autopsied.   The
cultures, sixty-seven in all, were made usually in the later
stages of disease.   In five cases of chronic disease bacteria
were found in the blood one or more days before death —

In two cases chronic nephritis, the streptoc. pyog.

One case Pott's disease and chronic nephritis, the streptoc. pyog.

One case gastric ulcer, staphyloc. pyog. aureus.

One case myocarditis and pericarditis, staphyloc. pyog. aureus.

These are considered cases of general terminal infection. In each of these five patients the invasion of the blood as shown by our cultures was followed within a few days by death.   The clinical aspect of these cases was not remarkable — any symptoms which may have occurred as a result of general infection were obscured by those which resulted from the chronic processes present.

In addition to the general infections in the chronic cases local infections were frequently found at autopsy, such as broncho-pneumonia, pleuritis, nephritis, etc. ; of these broncho-pneumonia was far the most common.

With reference to the occurrence of general blood invasion during the death agony, cultures of the heart blood were made immediately after death in thirty-five cases where no general infection was found during life.   These patients consist of seven septicemias, five cases of cerebro-spinal meningitis, sixteen of chronic disease, and seven of miscellaneous acute diseases.   We are struck by the fact that in these thirty-five cases only four positive results were obtained —

In one case mitral and aortic stenosis, the staphylococ. pyog. aureus.

One case mitral regurgitation, the staphylococ. pyog. aureus.

One case cancer of epiglottis, streptococcus pyogenes.

One case compound skull fracture, streptococcus pyogenes.

These are considered cases of probable agonal infection. We are satisfied that the large number of negative results represent the conditions that were actually present — that if any considerable number of bacteria had invaded the general circulation in the death agony some would have been found in the five c.c. of blood aspirated and used for cultures.

Only two varieties of bacteria were found, and these never

in mixed infection; the colon bacillus was not present in a single culture. The number of bacteria was small, as a rule, five to ten per c.c. of the staphylococci, and twenty to ninety streptococci per c.c. In four instances positive cultures were obtained both before and after death in the chronic cases, and in two of these latter there was apparently a growth of bacteria in the blood (or an increased invasion of the blood), for the second culture showed a considerably larger number present than the first. In the large majority of our chronic cases the blood both before and immediately after death proved sterile.

In five of our nine positive cases an autopsy was performed and the same bacteria which were present in the blood cultures were found distributed through the organs, as would be expected. In many of the chronic and miscellaneous cases, where blood cultures were negative, colon bacilli and certain other bacteria were found in one or more organs at autopsy a considerable number of hours after death. This we regard in most cases as purely a post-mortem phenomenon, resulting from the outgrowth of bacteria through the body after death.

In view of our results we cannot accept the theory that agonal invasion by colon bacilli and other bacteria is an easy and frequent occurrence, or the application of this theory to post-mortem findings. If autopsies are performed within a short time after death, and the results of post-mortem growth of bacteria in the body avoided, we have every reason to believe that in the majority of cases the bacteriological findings at autopsy correspond to conditions present during life.

In addition to the use of blood cultures certain evidence was obtained by the author from experiments with blood serum (given in a previous paper[1]), showing that human blood serum does not lose its germicidal power for the colon bacillus even in the late stages of chronic disease, and frequently retains its germicidal power for this bacillus for sev-

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[1] See this Journal, No. 3, vol. iii, 1898.

eral hours after death.   This fact may explain the infrequency of general agonal invasion by the colon bacillus.

Our conclusions may be summarized as follows:

1. Blood for bacteriological examination during life must be taken directly from the veins, and in considerable quantity.

2. Resorption of toxines is the most important feature of cases of sepsis; pyogenic bacteria invade the general circulation in a rather small proportion even of severe cases, and as a rule late in the course of disease.

3. A general infection by the pneumococcus can be demonstrated occasionally in the late stages of lobar pneumonia.

4. The value of blood cultures as a means of diagnosis in obscure cases of sepsis is limited by the fact that invasion of the blood by the specific organism cannot be demonstrated during life in the majority of cases.   Positive cultures are very valuable; negative cultures do not exclude local septic infection.

5. The detection of specific bacteria in the blood in cases of sepsis and pneumonia gives a very unfavorable prognosis in most cases.

6. General terminal infections with pyogenic cocci occasionally occur as an immediate cause of death in chronic disease.   Local infectious processes play this part more frequently.

7. As far as our experiments have shown, invasion of the blood by bacteria during the death agony, with subsequent distribution of the germs to the organs by the circulation, is a rather uncommon occurrence.

MOVEMENT OF THE FRONT OF THE FOOT IN WALKING.

E. H. BRADFORD.

The human foot differs from that of other animals in that it has an arch, formed by the posterior end of the os calcis and the heads of the metatarsals.

This is necessitated by the erect position of man; even among the higher apes the posterior part of the os calcis is not essential in weight bearing. There is in the ape a greater flexibility at the mediotarsal articulation, a proportionally greater length of the metatarsals (except the first), and a greater ab and adducting power of the first metatarsal, adapted to the arboreal traits of all apes and monkeys.

In man the great toe is never a thumb, but though the first metatarsal is the strongest of the metatarsals, it is limited in its ab and adducting motion. This limitation is seen even in the feet of Central African pigmies and of the prehistoric man, and shows that a missing link is needed in the foot to connect the descent of man from an arboreal ancestor. The relationship is, however, shown by the marked vestige of ab and adducting power of the first metatarsal, which is enough to indicate that if man was never fully arboreal he was given a foot meant to be prehensile.

In the gait of the monkey the claw-like action of the front of the foot is evident; a certain amount of this exists in man, and is shown in the up and down movement of the metatarsals.

This resembles a similar movement of the metacarpals in the hand, and as in the hand it is greatest in the first and fifth metatarsals and is somewhat less in the fourth, third, and second. The side play of the first and fifth metatarsals adds to the claw-like action.

In walking upon soft ground this claw-like action of the free foot is manifested by the depression made by the toes and heads of the metatarsals of the bared foot, the heel of the protruding foot is placed upon the ground and the body

pulled forward by the action of the glutei and hamstring muscles, the front of the foot is brought to the ground, and in energetic action the heads of the metatarsals and digits press upon the ground, to aid in propulsion.

In shoe-cramped feet the "claw-like" action of the front of the foot is impaired or lost, but in moccasined and bare-footed people, as well as in strong, undistorted feet, it is of great assistance in gait, and enables the individual to employ in locomotion to great advantage the inclined or forward gait common among savages, but difficult among shoe-wearing people, where the muscles of the sole of the foot are weakened.

DESCRIPTION OF PLATES.

FIG. 1.   Baboon walking, showing "claw-like" action of the feet.

FIG. 2.   Profile drawing of casts taken of human-foot impressions :

        a. Standing on soft clay, showing downward pressure on heel.

        b. Claw-like action of toes and metatarsal at end of the step.

        c. Full step, indicating pressure on the heel and claw-like action of metatarsal and toe.

FIG. 3.   Normal flexibility of front of the foot.

FIG. 4.   Soles of feet of a native of the Caroline Islands unaffected by shoes, and of a Caucasian altered by shoes.

PLATE I.

Fig. 1.
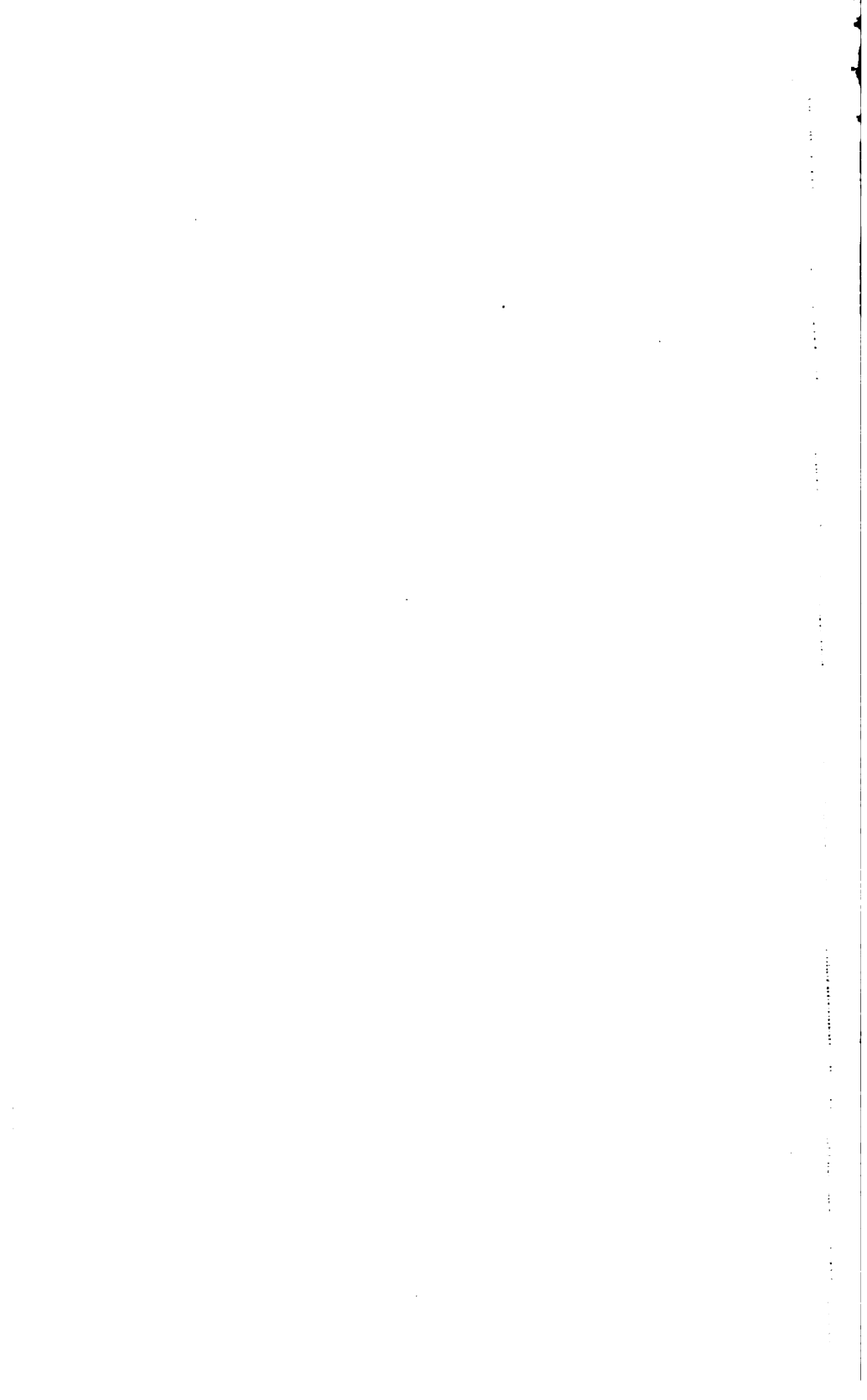
PLATE II.

Fig. 2.
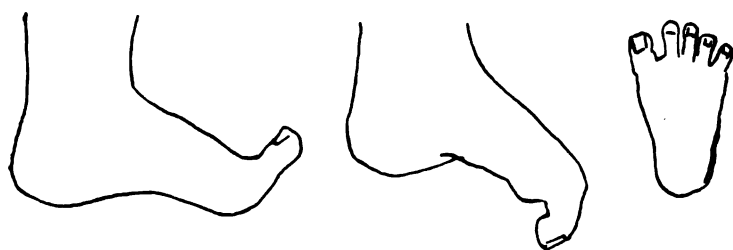
Fig. 3.

Fig. 4.

SYMPATHETIC GANGLIA AND BLOOD PRESSURE.[1]

ALLEN CLEGHORN.

(*From the Laboratory of Physiology in the Harvard Medical School.*)

It has been shown by Kose (1) and Stilling (2) that the sympathetic ganglia contain not only nerve cells, but also large polygonal cells which stain deeply in chromic acid. These cells are found also in the medulla of the suprarenal capsule, an extract of which when intravenously injected gives a large rise in blood-pressure. An extract prepared from sympathetic ganglia of the cat or dog when injected into the jugular or femoral vein gives a *fall* in blood-pressure. The character of this fall is not affected by division of the vagi. This property of lowering the blood-pressure belongs to the superior and inferior cervical, stellate, and the large ganglia contained in the solar plexus. Control experiments were done with spinal ganglia, spinal cord, brain matter, nerve and abdominal tissue, and with the glycerin and saline solutions employed; no results were obtained from any of these substances. The sympathetic extract was prepared by macerating the ganglia in glycerin for twenty-four hours, then enough saline solution (0.8%) was added to slightly thin the extract and the whole was filtered under pressure.

A mixture of this extract and defibrinated blood perfused through the isolated mammalian apex causes an enormous fall in the *tonus* of the heart muscle, while the contractions are considerably larger.

The muscular contractions of a frog poisoned with this extract are profoundly altered. Relaxation being considerably prolonged, while the latent period is also lengthened, the appearance of a curve taken from a poisoned muscle greatly resembles that obtained by veratrin. The muscle was stimulated by maximum break shocks both by direct and indirect methods.

Further work which is already under way is necessary to

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[1] Abstract, to be published in full in the American Journal of Physiology.

determine the nature of this substance and whether the fall
in blood-pressure caused by this extract is due to a central
or peripheral action.

1. Kose, W.   Sitzungsber. des Deutschen naturw.-med. Vereines f.
Böhmen " Lotus," 1898, No. 6.
2. Stilling, H.   Anatomischer Anzeiger, xv. 1898, p. 229.

REPORT OF SOME STUDIES UPON THE ARCH OF THE FOOT IN INFANCY.

John Dane, M.D.

It has been the generally accepted teaching, both in this country and abroad, that the foot of the infant and young child is flat. This statement is made in every text-book on Orthopedic Surgery and monograph upon the foot with which I am acquainted. They seem to have deduced this fact from a study of the wet or smoked tracings; and when one examines the print of the foot left upon a piece of smoked paper, or the imprint of the moistened sole upon a dry floor, the impression certainly is that it must have been made by a foot without a planter arch. Starting from this as a base line, it has been the customarily received theory that the planter arch was made, that is, pulled up, by action of the muscles in the course of their development. The tracings of the foot as the child grows up seemed to confirm this theory, and when the age of four or five years is reached, and the leg muscles have become firm, the tracing of the foot closely resembles that of the adult.

In studying the feet of children under two years of age certain facts did not agree with this teaching: first, measurements relative to the height of tubercle of the scaphoid and the proportion between this height and the total span of the arch. These were obtained in the following manner: Three points were marked upon the skin of the inner side of the foot — one over the metacarpo-phalangeal joint of the great toe, a second over the tubercle of the scaphoid, and the third as nearly over the hindmost point of the bearing surface of the inner tuberosity of the os calcis as could be determined. A flat piece of wood was pressed firmly against the sole of the foot, while the knee and thigh were controlled by the hands of an assistant. It was then easy to measure the height above this plane of the point over the tuberosity of the scaphoid, thus getting the actual height of the arch. The span of the arch was found by measuring the distance in a straight line between the other two points. The average height for infants of one year or under was found to be 1.651 cm.; between one and two years, 1.510 cm.

TABLE I.

Children under One Year — 76 Feet.

No.	Length of arch.		Height of arch.		Age.	Sex.
	Right.	Left.	Right.	Left.		
1..........	4.2 cm.	4.4 cm.	1.3 cm.	1.4 cm.	6 weeks.	Female (Jew).
2..........	4.8 "	4.7 "	1.4 "	1.5 "	6 "	Male.
3..........	5.0 "	5.0 "	1.2 "	1.1 "	6 "	Female.
4..........	5.4 "	5.5 "	1.6 "	1.6 "	7 "	Male.
5..........	4.0 "	4.2 "	1.2 "	1.3 "	2 months.	"
6..........	4.8 "	5.2 "	1.2 "	1.6 "	2 "	"
7..........	5.0 "	5.0 "	1.3 "	1.4 "	2 "	"
8..........	5.2 "	5.0 "	1.7 "	1.6 "	2 "	"
9..........	5.4 "	5.2 "	1.5 "	1.4 "	3 "	Female.
10..........	5.4 "	5.4 "	1.7 "	1.5 "	3 "	"
11..........	6.2 "	5.8 "	1.7 "	1.6 "	3 "	Male.
12..........	5.3 "	5.5 "	1.5 "	1.5 "	4 "	"
13..........	5.4 "	5.3 "	1.6 "	1.6 "	4 "	Female.
14..........	5.6 "	5.6 "	1.5 "	1.7 "	4 "	Male (Jew).
15..........	5.8 "	5.7 "	1.8 "	1.6 "	4 "	"
16..........	4.7 "	4.7 "	1.4 "	1.5 "	4½ "	Female (Jew).
17..........	5.1 "	5.1 "	1.7 "	1.4 "	4½ "	"
18..........	6.2 "	6.0 "	2.0 "	1.8 "	5 "	"
19..........	5.5 "	6.0 "	2.0 "	1.8 "	6 "	"
20..........	5.6 "	5.8 "	1.7 "	2.0 "	6 "	Male.
21..........	6.4 "	6.4 "	1.8 "	1.7 "	6 "	Female.
22..........	4.8 "	5.0 "	1.8 "	1.2 "	7 "	"
23..........	5.4 "	5.7 "	1.5 "	1.6 "	7 "	Male.
24..........	5.8 "	5.5 "	1.7 "	1.7 "	7 "	Female.
25..........	5.8 "	6.2 "	2.0 "	2.0 "	7 "	"
26..........	6.0 "	6.0 "	1.8 "	1.8 "	7 "	"
27..........	6.0 "	6.0 "	2.0 "	1.8 "	7½ "	"
28..........	6.4 "	6.5 "	1.8 "	1.5 "	7½ "	Male.
29..........	5.0 "	5.0 "	1.5 "	1.6 "	8 "	Female.

TABLE I. — *Continued.*

No.	Length of arch.		Height of arch.		Age.	Sex.
	Right.	Left.	Right.	Left.		
30	5.0 cm.	5.2 cm.	1.4 cm.	1.4 cm.	8 months.	Male.
31	5.1 "	5.0 "	1.8 "	1.4 "	8 "	"
32	6.6 "	6.6 "	2.0 "	1.7 "	8½ "	"
33	5.3 "	5.6 "	1.5 "	1.6 "	9 "	"
34	5.5 "	6.0 "	1.6 "	2.0 "	9 "	Female.
35	6.0 "	6.0 "	2.0 "	1.4 "	10 "	Male.
36	5.4 "	5.5 "	2.2 "	2.2 "	11 "	"
37	6.0 "	6.0 "	2.2 "	2.2 "	11 "	Female.
38	6.1 "	6.1 "	2.0 "	2.2 "	12 "	Male.

Average length of arch . . . . . 5.481 cm.
 " height of arch . . . . . 1.651 "
Proportion, length to height . . . . 0.301 "

TABLE II.

Children between One and Two Years.

No.	Length of arch.		Height of arch.		Age.	Sex.
	Right.	Left.	Right.	Left.		
1	6.0 cm.	6.5 cm.	1.8 cm.	1.6 cm.	13 months.	Male.
2	7.0 "	7.6 "	1.4 "	1.7 "	13 "	"
3	6.3 "	6.0 "	2.0 "	2.0 "	14 "	"
4	6.6 "	6.4 "	1.8 "	2.0 "	14 "	Female (negro).
5	6.6 "	6.7 "	2.3 "	2.0 "	14 "	"
6	7.2 "	7.0 "	2.6 "	2.3 "	15 "	"
7	6.5 "	6.4 "	2.0 "	2.3 "	16 "	"
8	8.0 "	7.5 "	2.5 "	2.0 "	18 "	Male.
9	7.5 "	7.6 "	2.1 "	1.5 "	21 "	Female.
10	7.5 "	7.5 "	2.3 "	2.3 "	22 "	Male.

Average length of arch . . . . . 6.905 cm.
 " height of arch . . . . . 1.510 "
Proportion, length to height . . . . 0.218 "

Or, taking the proportion of the height of the arch to its length, we have the fractions 0.301 and 0.218 as the average for the same periods of time. The adult proportion is about 0.270. This is not exactly what one would expect to find if the feet were really flat; for it shows that the essential structure — that is to say, the arch formed by the bones — not only exists at the earliest period of life, but that it is fully as high proportionally at this as at any subsequent time. Tables I. and II. show the actual figures as they were made during this study.

The explanation of the apparent difference between these figures and the smoked tracings I believe that I have found in the examination of some hardened sections of the feet or young children. Fig. I. is from a photograph of the foot of a child eighteen months old.

Figs. II. and III. are sections through the ankle-joint and mediotarsal joint respectively. They show clearly the bones of the foot arranged so as to form a good arch, but they show only indistinctly that the hollow of this arch is filled up with a pad of fat. It is the presence of this pad of fat that causes the smoked and wet tracings to show an absence of the arch. I am therefore led to believe that the foot of the human infant has an arch as high and well developed as that of the adult, and that the bones composing it are from the very beginning so shaped as to form an arch, and in these relations to each other they should be developed and finally become ossified. This arch is, of course, a very delicate structure for the first year or two of life. During this period the leg muscles and intrinsic muscles of the foot are so little developed that they would be manifestly unable to hold up the arch when pressed upon by the weight of the growing child, much less to build it up against that pressure.

The arch is, therefore, supported throughout its entire span by a pad of relatively firm fat. Examination of the feet of almost all well-nourished infants seems to show the presence of this pad, which I can regard in no other way than that of a physiological flat-foot plate. As development goes on, the leg muscles are brought into action, and by the third or

PLATE I.

Fig. 1.

Fig. 2.
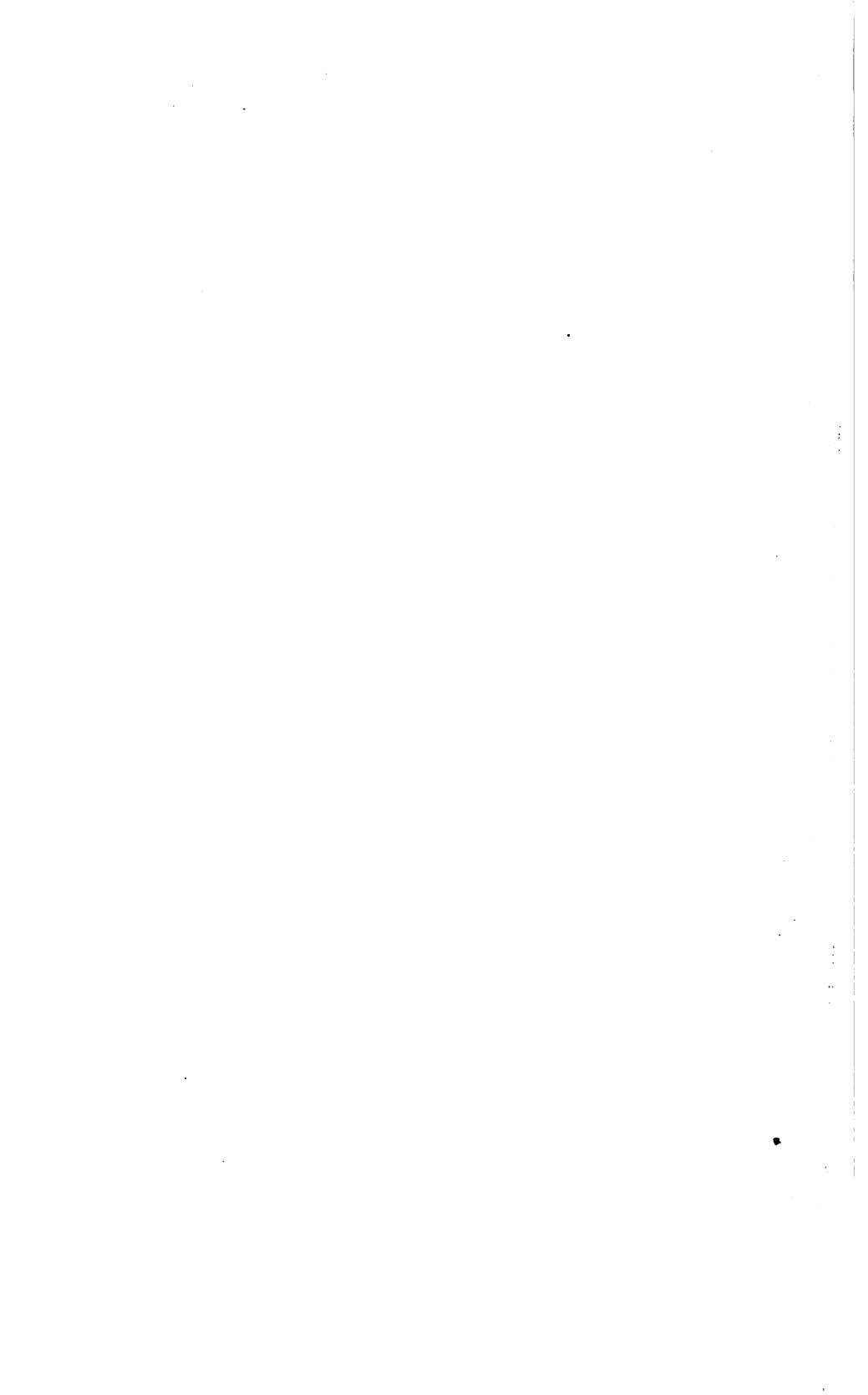
PLATE II.

Fig. 3.

Fig. 4.

fourth year have gained sufficient strength to support the arch of the foot without assistance. The pad of fat, being then no longer necessary, is absorbed, and as a consequence the arch of the foot appears in the wet tracings.

Fig. IV. is the longitudinal section of the foot of an infant premature at the eighth month, that died some days after birth. It shows the condition of the arch fairly well.

[*Erratum.* — Vol. III., p. 118. In lettering the plates of Dr. Beyer's article Plates I. and II. have been reversed. Plate I. should be marked *Exits*, and Plate II. should be marked *Entrances*. — Editor.]

SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on March 21, at the Harvard Medical School, at 8 P.M.

All communications should be addressed to the Editor,

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688 Boylston Street,
Boston, Massachusetts, U.S.A.

CONTENTS.

A NON–VIBRATORY BENCH FOR PHOTO–MICROGRAPHY.

W. R. BRINCKERHOFF, S.B.

(*From the Sears Laboratory of Pathology.*)

Workers in the field of photo-micrography are frequently troubled by the jarring of the apparatus due to passing traffic. This is particularly annoying when the work is done in a large city, and many devices have been tried to overcome the difficulty.

There are two ways in which this floor-vibration can be prevented from reaching the apparatus. First, by deriving the support for the table from bed-rock by means of masonry pillars; second, by interposing between the apparatus and the floor some elastic substance. By the first method the vibrations of the floor and building are eliminated; by the second they are all absorbed. The bench which I am about to describe is built upon the principle of elastic support.

The complete photo-micrographic apparatus may be considered as being composed of four parts: First, the light; second, such condensers, heat absorption tanks, and color-screens as may be needed to concentrate and modify the light in such manner as may give the best illumination of the slide; third, a microscope to hold the slide and project the

image of the object; and fourth, a camera to hold the photographic plate which is to receive that image.

In the present apparatus the first three of these are placed upon one table, the optical bench, and the fourth upon a second, the camera table. These two tables are fastened securely to each other by braces, a space of 60 cm. being left between their ends, the whole apparatus standing on a false floor, which, in turn, rests upon eighteen thin-walled rubber balls filled with compressed air.[1] These balls prevent the vibrations of the floor from reaching the apparatus, much as the pneumatic tire of a bicycle prevents the inequalities of the road from being felt by the rider.

In the interval between the optical bench and the camera table is placed a stool (supported directly from the floor) on which the operator sits while manipulating the microscope and selecting the field to be photographed. (See Fig. 1.)

The camera is mounted upon a board which slides on rails upon the camera table. When the photograph is to be taken the camera is drawn forward and locked to the optical bench, the microscope tube then engages the front of the camera, and the exposure can be made.

The bench which is the subject of this article was built by a carpenter under my direction at a very slight expense, and has been used in taking over a thousand photo-micrographs. Of that number not a single failure could be attributed to vibration, although the floor of the room can be felt to shake when a heavy team passes the building.

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[1] The 6-in. Clifton air-ball.

DESCRIPTION OF PLATE.

FIG. 1. Non-vibratory photo-micrographic bench. Camera drawn back to allow operator to manipulate microscope and select field to be photographed.

FIG. 2. Camera drawn forward and locked to optical bench. Ready for exposure of plate.

PLATE I.
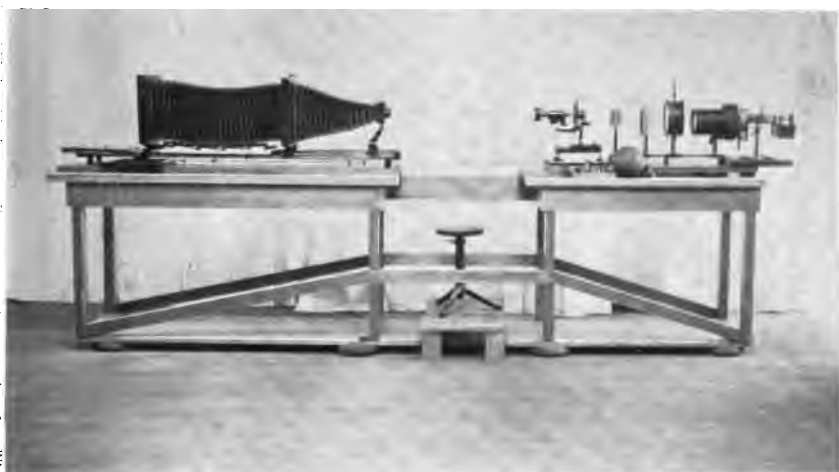
FIG. 1.
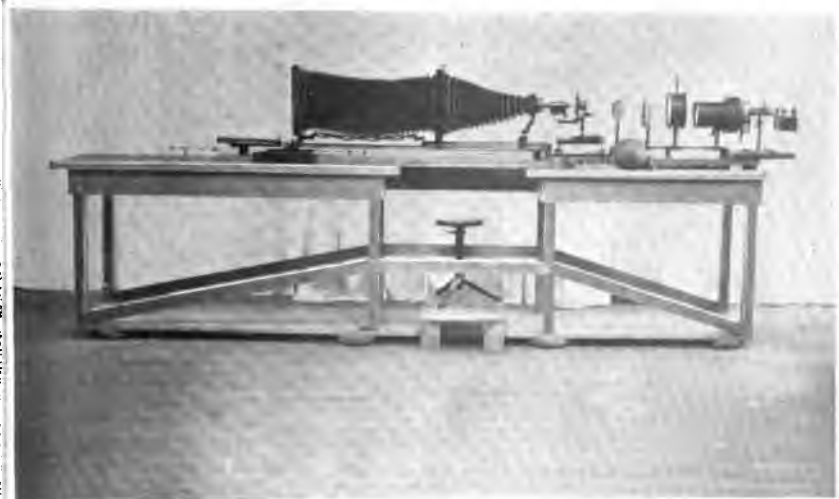
FIG. 2
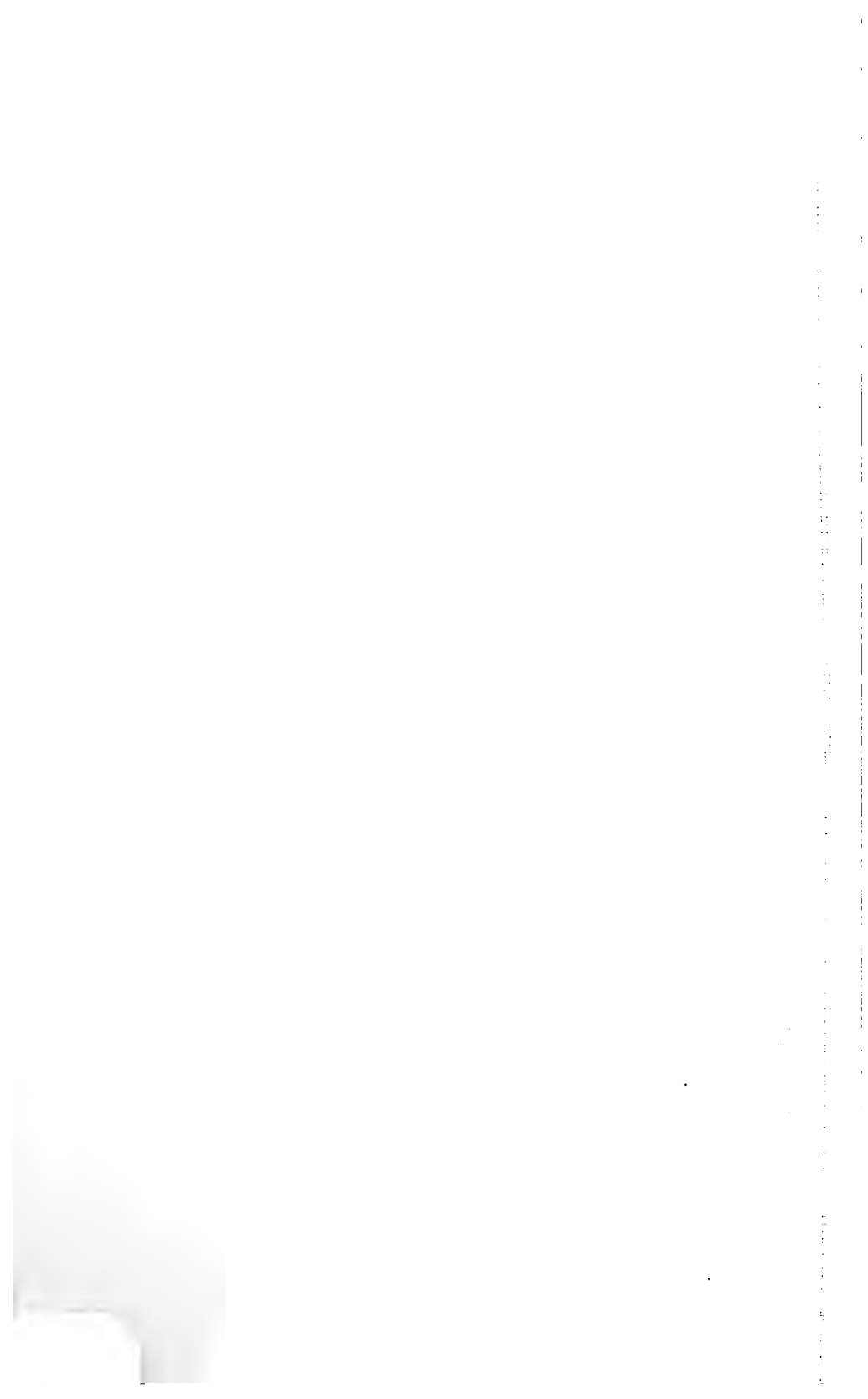
INFLUENCE OF BILE ON METABOLISM.

ELLIOTT P. JOSLIN.

(From the laboratories of the Harvard Medical School and the Massachusetts General Hospital, under the direction of Dr. Franz Pfaff.)

The incentive to this work came from my friend and instructor Dr. Franz Pfaff, to whose unvarying interest, suggestions, and encouragement it is chiefly due. In an article by Dr. Pfaff and Alfred W. Balch[1] on " An Experimental Investigation of Some of the Conditions Influencing the Secretion and Composition of Human Bile," it was shown that human bile, oxbile, and bile salts when given to a patient with complete biliary fistula had a marked cholagogic action. The experiment extended over a period of ninety-seven days, and represents the most complete study of the question on a human being yet produced.

During this investigation it was observed that while the patient was taking bile in one form or another the appetite improved, the bowels moved without medication, and the stools diminished in bulk, but increased in consistency and color.

The above article closes with the following paragraph: " For the present we will only say that bile may be useful in those cases where so-called cholagogues are now prescribed as well as in certain cases of constipation, and possibly cases where we wish to increase the absorption of fat."

The influence of bile on metabolism has been chiefly studied in a negative way by observing the changes which have occurred when bile was removed from the intestinal tract by means of a biliary fistula. In the present instance the effect of bile has been shown in a positive manner by the direct administration of the same under similar conditions.

The present study was made upon[2] a woman of fifty-four

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[1] The Journal of Experimental Medicine, Vol. II., No. 1, 1897.

A preliminary report of a portion of the work done under the provisions of the second Dalton Scholarship at the Massachusetts General Hospital for the years 1898–1899.

[2] The patient was in the services of Dr. H. H. A. Beach and Dr. Maurice H. Richardson at the Massachusetts General Hospital, and the operation was performed by Dr. S. J. Mixter. To all these gentlemen I am especially indebted for the privilege of conducting these investigations.

years of age who had suffered from attacks of gall-stones covering a period of three years. She was operated upon in the hospital, but her condition was so critical that the gall bladder alone was emptied of stones. She rallied quickly from the operation. The stools were colorless, and chemical tests failed to show the presence of bile acids. As it seemed best for her to remain in the hospital for some time to gain strength, the opportunity was afforded for special study of the case, which was carried on between December 20 and December 31, inclusive.

During the preceding fourteen months the action of bile on the metabolism of a healthy individual had been investigated and the same question studied on four dogs, upon whom the common duct was ligated and cut and a biliary fistula then made. The results thus obtained, together with the complete account of this case, will be reported later.

This experiment was divided into three similar periods of four days each, except that in the second period the patient received thirty grams of dried oxbile. The beginning and end of the experiment and the different periods were all marked off by the patient's taking the charcoal mixture recommended by Müller. In each instance the change in the period was definite. During the twelve days the patient passed about two-thirds of the twenty-four hours in bed, and for the remainder of the day was about the ward. The bowels showed no tendency at any time to constipation or diarrhœa.

· During this time the diet of the patient consisted essentially of bread and butter, thin cream, eggs, sugar, and beef. The per cent. of nitrogen and fat was determined in each article of food, daily double analyses being made in the case of the thin cream. All the food was prepared in the laboratory by Mrs. Lillian Osborne, the assistant in the chemical laboratory of the Massachusetts General Hospital.

The urine was collected daily and the amount and specific gravity noted. The nitrogen in two portions of 5 cc. from the twenty-four hours' amount was determined by the Kjeldahl method, and the urea with Squibb's apparatus. The stools for each period, with the wash-water made use of in cleaning

the utensils, were made slightly acid with a few drops of con-
centrated sulphuric acid, and were then evaporated over the
water-bath, especial care being taken that they be thoroughly
and frequently stirred.   The stools did not become solid
while over the water-bath, but on removal from the same
assumed a firm consistency, though not sufficiently so to
allow of reduction to a powder.   They were then weighed
and the total per cent. of fat determined by double analyses.

The bile was collected at six-hour intervals and the amount,
specific gravity, and the per cent. of solids in the twenty-four
hours' amount determined.   The fistula caused much annoy-
ance, as it did not admit of the satisfactory use of a Pegram's
cannula.   Dr. LeCompte tried many other devices, but it
was impossible to prevent leakage.   On this account the
bile, not collected in the flask the patient wore, was caught
in the dressings which were arranged for this purpose.   The
bile was then removed from them by repeated soakings in
water, which was later siphoned off, filtered, and the filtrate
evaporated to constant weight, which weight was that of the
dried bile.   As the per cent. of solids in the bile each day
had been calculated, the amount of bile absorbed in the dress-
ings was easily estimated.   That the method was sufficiently
accurate is shown by a comparison of the amount of bile in
the first and third periods (which is seen to be nearly the
same), because in the first period there was no leakage from
the cannula, while in the third but a half was secured in this
way, the remainder being caught in the dressings.

Bile was given to the patient in the second period in the
form of bile pills.   Each pill represented 0.25 grams dried
oxbile.   To render these more palatable and less liable to
change in the stomach they were coated with salol — 59
grains to the 100 pills.   Of these the patient took 30 daily,
a total of 120 in 4 days, or 30 grams oxbile and 4 grams
salol.

Following the above plan, the results which are sum-
marized below were obtained:

1. The amount of urine increased over 50 per cent. in the
bile period.   V. Noorden has recorded a similar increase in

the amount of urine following the removal of the obstruction in acute catarrhal jaundice. But so far as I am aware the diuretic effect of bile *per se* has not as yet been proven. That the salol coating, which amounted to about 1 gram a day, is not sufficient to account for this diuretic action of the bile pills is evident from the work of Kumagawa who gave 2 grams sodium salicylate daily to a dog of 25 kilos, without essentially changing the amount of urine secreted. Though various authors speak of the diurectic action of salol, none have refuted Kumagawa's experiments, and none have claimed for it an action equivalent to that recorded in this experiment.

2. The per cent. of fat lost in the stools in our patient was 63 per cent., which closely corresponds to the results Müller obtained in human beings and dogs with complete obstruction of the common duct. Under bile medication the stools contained 23 per cent. less fat than in the first period, and 17 per cent. less than in the third. This represents an actual diminution of the amount of fat lost in the stools. Looking at it from another standpoint, the average digestion of fat in the periods without bile was 40 per cent. ; when bile was given with the food this figure rose to 60 per cent., — *i.e.*, bile increased the digestion of fat relatively by 50 per cent.

3. Thirdly, there was a marked improvement in the assimilation of nitrogen by the body. Instead of an average of 15 per cent. being lost in the faeces, but 7 per cent. escaped digestion during the four days the patient took bile. The reason for this, perhaps, lies in the better digestion of fat at this time, and the better exposure thereby of the proteid elements of the food to the digestive juices.

4. The amount of bile solids secreted in the bile period was 47 per cent. greater than in the periods coming before and after, and thus affords confirmation to the work of Pfaff and Balch here in Boston on a human being, and that of Stadelmann and his pupils in Germany on dogs.

5. Your attention is called to the statement in the article above cited that no constipation was experienced by the patient while she took bile. Though the bowels moved daily

throughout the whole of our experiment the patient tells me that when taking bile pills they always moved more satisfactorily.   It is by no means every case of sluggish bowels which finds stimulation in bile pills, and at present I know of no way of determining cases suited to their action save by empirical means.

6. As to the general effect of bile on body metabolism, it was observed that the urea and nitrogen were secreted in greater amount in the bile period than in either of the others. No definite conclusions can be drawn from this fact, because more nitrogen was ingested during these four days; and even apart from this it must be borne in mind that in this regard salol alone can play an important rôle.

Since the conclusion of this experiment the patient has been operated upon again. The common duct was found occluded with gall-stones of soft consistency. These were removed by an incision in the duct, and its complete patency into the duodenum once more established. The fistula has ceased to discharge and the patient is now well. This happy outcome led Mrs. Mc. to undergo another metabolism xperiment of three days' duration for the purpose of comparing her digestion in health with that when no bile was able to enter the intestine, and the results will be briefly stated.

1. The volume of urine was 815 cc. per day, which is about the amount of the second period of the first experiment in which the patient was artificially supplied with bile. This lends weight to the conclusion already reached that bile is a diuretic.

2. The amount of fat lost in the stools was about 15 per cent. of that ingested.

EFFECT OF THE LIGHT THROUGH THE EYELIDS ON AFTER-IMAGES IN RESPECT TO DURATION AND COLOR.

B. JOY JEFFRIES, M.D.

Continuation of after-images is affected by the light which passes through the lid or lids.

The duration of the after-image is twice as long when such light keeps up the stimulation as when it is completely shut off.

This light coming through the lids is colored purplish-red by the blood-stream in the lids. Such color is therefore added to the color of the after-image, hence affecting the complementary colored after-image.

We obtain with closed lids no true complementary color so long as the general illumination is sufficient to be noticed, which need be no more than that used in getting the after-image.

That a good deal of light passes through the simply closed lids, and hence a good deal of retinal stimulation, is very practically shown by our habit of crushing them together when exposed to too strong light, and our finally being forced to turn away from it.

Continuously passing objects, as we well know from experience, cause giddiness. Soldiers can not long keep their eyes open, presenting arms to troops marching past close to them. A hand waved close to the eyes from side to side causes the same disturbance. This disturbance is rather increased by closing the lids when facing a bright light, the retina seeming less able to bear the moving shadow when deprived largely of its form distinction.

It is this stimulation of light through the lid which keeps up the retinal impression, the negative after-image. Covering the closed lids with the hands so as to exclude all light, but not touching the lids, causes the after-image to disappear, to again appear on removing the hands and getting the stimulation of light through the lids. The negative image lasts long enough to do this repeatedly. But *also*, the after-

image returns slowly and more feeble behind the closed and covered lids on retinal adaptation.   This experience may be had in using only one eye, then of course less marked.   An after-image taken with *one* eye, the other *closed* but not *covered*, becomes fainter on *covering* the closed eye, — the light stimulation through the lid of the eye *not* used assisting the effect in the *used* eye.   -

After-images with closed lids last twice as long when the lids receive the same light as when they were open.   A 20 or 30 second image lasts 60 seconds with lid light, and only 20 to 30 when the lids are covered by the hands to exclude all light.   When wholly gone under closed and covered lids for 20 to 30 seconds, the image will again return when the hands are removed and the light is allowed to pass through the simply *closed* lids.

Light coming through the lids has to pass ʹthe blood-. stream, and so must be colored by it, whether this light reaches the retina through the pupil or through the sclerotic.

Gazing with closed lids, if we may use the expression, at a strongly illuminated surface or a light, the blood-stream colors the field a *purplish-red*, perhaps best represented by a sheet of purplish-red gelatine held up before the open eyes.

We get the color through our fingers when the open hand is held between our eye and a strong light.   Still more definitely as suggested by Snellen, when we cover one opening of a stethoscope with the finger tip, and look through the tube towards a strong light, the other eye closed.   When the eyes are closed, and there is sufficient light, the whole retina is affected by this purplish-red color.   When the eyes are open the light through the pupil is not affected.   It is, however, then passing through the sclerotic, but not noticed.   It will cause its complementary color to appear on the portion of the retina unaffected by it, under certain conditions.

If we make an opening 3 mm. in diameter in the centre of a purplish-red sheet of gelatine, and look through it at the sky, we shall have a purplish-red field, with the central opening uncolored.   Soon, however, from contrast this will appear greenish.   Now removing the gelatine sheet and looking at

a surface not too bright, the red field, of course, is gone, and the green spot has changed to red.

* Snellen showed that this was precisely the condition we have in erythropsie induced by bright snow light; namely, that a portion of the retina has been affected by light through the lids, increased if they are inflamed by sunburn, and the rest of the retina has received white light through the pupil. This overpowers the purplish-red impression, till we pass, for instance, into a shaded room, when lighted surfaces appear reddish and shaded greenish from simultaneous contrast.

This study of the blood-stream in the lids has thus seemingly explained the cause of erythropsie, or the red glare often complained of by patients after cataract operation, especially if an iridectomy has been made. The same with congenital coloboma, and whenever the pupil is unnaturally enlarged and kept so by paralysis or mydriatics; also, of course, with normal eyes, the red glare after exposure to snow or very bright light.

The albino's suffering or discomfort is probably not only due to lack of pigment in the choroid, but his color sense is *always* affected by the mixture of the purplish-red of the blood-stream in his lids.

It would be an interesting point to ascertain if the colored race are less subject to snow erythropsie, and in proportion to the depth of pigment in the lids which must help to prevent light passing through the sclerotic.

Erythropsie has been long known and quite a literature shows that it has been well studied. Professor Fuchs, of Vienna, personally experienced it, and investigated it very thoroughly. In his critical resumé and most suggestive study, he finally admits being unable to explain the cause, which the blood-stream now makes so simple in its affecting a portion only of the retina.

Fuchs found that colored glasses had little effect in preventing erythropsie till he tried red. By this the whole retina was under the influence of the same color as that passing through the lids.

The purplish-red color of the blood-stream ought to be

stopped by interposing a transparent complementary color between our closed lids and the bright light we look at. This is readily done by a plate of green glass, or a sheet of thin green paper, the complementary after-image of which corresponds to the color of the blood-stream. The green paper takes away all color, but enough light still passes to allow the retina to feel the shadow of a passing hand.

When the light is bright enough to pass the lids and give a purplish-red color, it must affect after-images, since we have seen that the lid light affects them. That is, white after-images of dark or black objects must assume a purplish-red color. Moreover, complementary colored after-images must be altered by such additional color.

This is very readily determined by projecting on a dark surface the after-image of a dark object. It appears whitish or pale bluish-white. Now, if we gently close the lids, allowing to fall on them simply the same light in which we took the after-image, the image very quickly commences to turn to the color of the blood-stream. After it has assumed its full color, if we open the eyes and again gaze at the dark surface, the after-image appears green induced by contrast with the blood-stream color. The same change to green will finally come under the closed lids, and the after-image may last long enough to allow us to again see our white after-image on the dark surface.

This can be observed when using only one eye, but of course much more distinctly in doubling the impression in power by the use of both eyes together.

The blood-stream color must affect the color of complementary after-images. This is shown in various ways. A red square gives a greenish after-image. Now, look at a bright light with closed lids and we have a general reddish field on which the green square after-image loses its color, which it assumes again on turning away and looking at a whitish surface, the white surface getting a reddish tinge.

The red after-image of a green square is made deeper in color by the addition of the blood-stream color through the closed lids, in gazing at a bright light.

· As is well known, closing and covering the left eye and holding a red glass before the right we shall have a green right after-image on removing the red glass, and on opening the left eye a red one when looking at a white surface.   But this red left after-image is assisted by only *closing* left lids and not also *covering* them to exclude all light when getting the after-image with the right eye.

We get, however, the same effect by simply using the blood-stream instead of the red glass before the right eye.   Closing and covering the left eye and simply closing the right, if we look steadily at a very bright surface we shall, on opening the eyes, get a green after-image in right and red in left, precisely as with the red glass.

Now, a blue glass before the right eye, whilst left is simply closed, gives us, on removing the blue glass, a yellow after-image for the right eye, but the after-image for the left when opened is not the blue of the glass, it is altered by the blood-stream color, which alteration does not take place when the left is closed *and* covered.

Of the color-blind, those defective in red and green (viz., 4 per cent. of males and one-fourth of 1 per cent. of females) must naturally be peculiarly affected by the blood-stream.   Reds and greens are made still darker in complementary after-images, whilst yellow and blue would be but little altered.   Is it possible that their well-recognized peculiar look, due apparently to position of the lids, is dependent on the different light they receive through the lids from the normal eyed?

OBSERVATIONS ON THE STERILIZATION OF CATGUT.

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The purpose of this series of experiments was to test the practicability of sterilizing catgut for surgical use, first by dry heat, and second by dry paraform gas. Two points only were considered, viz., the effectiveness of the sterilization by these two methods and their effect on the tensile strength of the gut.

The difficulty which has been met in sterilizing catgut by baking has been that it is very easily charred, so that it becomes shriveled and brittle on exposure to a temperature high enough to sterilize it. This may be effectually prevented by wrapping the separate strands in several layers of paraffine paper. This simple procedure prevents the driving out of the moisture and fat in the catgut, so that it remains unshrivelled and flexible after a prolonged exposure to dry heat. Paraffine paper was first used in this way by Boeckmann, of St. Paul, and it has since been successfully employed by Dr. F. W. Johnson and others. Following Koch's classical experiments in sterilization, the temperature and time of baking has usually been 140° C. for three hours. I have examined samples from about 20 lots sterilized in this way and have found all sterile with one exception, where it was afterwards learned that a lower temperature than 140° had been used in the baking. The following table shows the results in a series of observations in which a higher temperature — from 140° to 160° C. — was employed for one hour.

Experiment.	Size of Catgut.	Temperature and time of sterilization.	Strands tested.	Culture tests.	Breaking Strength.		Gain or loss in strength.
					Before sterilization. Average of 10 tests.	After sterilization. Average of 10 tests.	
	No.				Gm.	Gm.	
I.	1	145° C. — 1 hr.	12	All sterile	3,384	3,518	+ 4% ⎫ Average loss = 9.5%
II.	1	{ 140° C. — 1 hr. / 160° C. — 5 min. }	5	"	3,384	2,852	• — 16% ⎬
III.	1	140°–150° C. — 1 hr.	5	"	3,384	2,817	— 17% ⎭
IV.	∞	140°–145° C. — 1 hr.	12	"	2,056	1,890	— 8% ⎫ Average loss = 6.5%
V.	∞	{ 140° C. — 1 hr. / 160° C. — 5 min. }	5	"	2,056	1,985	— 3% ⎬
VI.	∞	140°–150° C. —1 hr.	5	"	2,056	1,886	— 8% ⎭

The test for sterility was placing a strand in clear sterile bouillon and incubating for a week at 37.5° C. Any growth occurring in the cultures could be readily seen, but in all cases a doubtful cloudiness was tested for bacteria by sub-cultures on agar. The strands after subjection to a temperature of 140° to 160° C. seemed a little drier than before, but were not brittle nor discolored.

The effect on the strength of the gut seemed to be a slight loss. The exact effect is difficult to determine, because of the variation in strength between different strands of the same size and indeed between different parts of the same strand. However, by taking an average of ten tests in each instance an approximate idea can be obtained of the strength of any given lot. The average loss in strength in thirty tests of No. 1 gut was 9.5 per cent., of No. 00, 6.5 per cent. — not sufficient to affect materially its serviceability for ordinary surgical work.

The paraform method of sterilizing catgut was suggested by Dr. Charles Harrington in a communication to this society about a year ago. It seemed so simple and effectual that it was thought worth while to repeat his experiments for veri-

fication. The method, in brief, consists in exposing the cat-
gut to dry paraform gas for a period of several days. The
gas is volatilized from paraform pastilles at ordinary temper-
ature. Dr. Harrington's experiments showed a rapid and
effectual sterilization, sample strands in all instances giving
no growth in bouillon after from twenty-four to forty-eight
hours' exposure to the gas.

The following experiments were in close imitation of those
of Dr. Harrington. In the first series, strands of ordinary
commercial catgut of various sizes were cut into short pieces
and placed in a preparation jar, in the bottom of which was a
small cup containing a dozen fresh pastilles covered with a
piece of wire gauze. The jar was tightly covered and left
at room temperature. At frequent intervals three strands
of each size were withdrawn with sterile forceps and placed
in tubes of sterile bouillon, which were then incubated for a
week at 37.5° C. The percentages in the following table in-
dicate the number of cultures remaining clear, 100 per cent.
meaning that all the strands tested were sterile:

Experiment.	Numbers.	1 Day.	2 Days.	3 Days.	4 Days.	5 Days.	6 Days.	9 Days.	10 Days.	11 Days.	13 Days.	15 Days.	16 Days.	20 Days.	27 Days.	49 Days.
			Ster-ile.													
I.	00, 1, 3 · ·	· · · ·	55.5%	55.5%	· · · ·	77.7%	· · · ·	· · · ·	100%							
II.	00, 1, 2, 3,	· · · ·	50%	· · · ·	· · · ·	· · · ·	58.3%	· · · ·	83.3%	· · · ·	· · · ·	100%				
III.	00, 1, 2, 3,	· · · ·	66.6%	· · · ·	66.6%	· · · ·	· · · ·	· · · ·	· · · ·	91.6%	· · · ·	· · · ·	· · · ·	· · · ·	· · · ·	100%
IV.	00, 1, 2, 3,	50%	· · · · · ·	· · · ·	50%	· · · ·	· · · ·	83.3%	· · · ·	· · · ·	· · · ·	· · · ·	83.3%			
V.	00, 1, 2, 3,	· · · ·	50%	· · · ·	· · · ·	· · · ·	66.6%	· · · ·	· · · ·	· · · ·	75%	· · · ·	· · · ·	66.6%	91.6%	

It will be seen that in Exp. I. 100 per cent. of sterility was
obtained on the tenth day, in Exp. II. on the fifteenth day,
and in Exp. III. on the forty-ninth day. In Exps. IV. and
V. cultures made on the sixteenth and twenty-seventh days
respectively still showed a small proportion of unsterilized
strands.

Two other experiments were tried, to test the effect of

paraform gas upon catgut which had been impregnated with some of the common bacteria. A number of strands of catgut sterilized by dry heat were soaked for several days in pure cultures in bouillon of several varieties of bacteria. They were then removed, dried for twenty-four hours in sterile Petri dishes and placed in a jar with the paraform pastilles as in the previous experiments. Control cultures gave abundant growths of all the forms. In the first experiment the staphylococcus pyogenes aureus and the B. pyocyaneus were used, and specimen strands withdrawn after an exposure of twenty-two days still gave a growth of those microorganisms. In the second experiment, B. prodigiosus, B. pyocyaneus, and B. of anthrax were killed in twenty-four hours; B. diphtheriae gave a growth after twenty-four hours, but not after eleven days, while staphylococcus pyogenes aureus, B. of typhoid and B. subtilis gave profuse growths after eleven days' exposure to the paraform gas.

These observations prove the doubtful value of this method of sterilizing catgut. The dry gas has an unquestioned germicidal action, but it is too slow and its results are too uncertain to render it of service for surgical purposes — at least by the method employed in these experiments. A few strength tests showed, as already pointed out by Dr. Harrington, that the gas has no marked effect on the strength of the gut.

In connection with these experiments a few observations were made on the effect on the strength of catgut of soaking in various fluids, which are or have been commonly employed in its sterilization.

	BREAKING STRENGTH. Average of 10 Tests.		Loss in Strength.
	Before.	After.	
Water, 5 min. to $\frac{1}{2}$ hr..............	2,375 gm.	738 gm.	69%
$HgCl_2 - \frac{1}{1000}$, 2 days.............	"	681.5 "	71%
Glycerine, pure, 7 days	"	1173 "	51%
Glycerine, 50%, 8 days	"	734.5 "	69%
Ether, 2 days	"	1814.5 "	24%
Alcohol, 95%, 2 days	"	1771 "	25%
Alcohol, Absolute, 13 days.........	"	1630 "	31%
Ether, 16 days, $HgCl_2 \frac{1}{1000}$, 2 days ..	"	923.5 "	61%

It was found that a short soaking in any of the fluids caused a decided loss of strength. Water and solutions in water such as $HgCl_2 \frac{1}{1000}$ especially weakened the gut, while alcohol and ether had a much less though still a marked effect. This is of practical importance, because, whatever the method of sterilization, it is customary to place the strands in an antiseptic solution such as $HgCl_2 \frac{1}{1000}$ for a few minutes before using to render them soft and pliable. These few minutes are enough to cause a very great loss of strength, — about 70 per cent., — so that the strength when used, the available strength, is always much less than the figures given above would indicate. This only emphasizes the importance of employing a method of sterilization which will preserve the original strength as far as possible.

Summary: 1. Catgut can be sterilized by dry heat with but slight loss of tensile strength.

2. Dry paraform gas is of doubtful value for the sterilization of catgut.

3. Methods of sterilization which involve soaking in antiseptic solutions tend to weaken the catgut to a greater or less degree.

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THE INFLUENZA BACILLUS AND PNEUMONIA.

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An analysis of the autopsy records of the Massachusetts General Hospital was recently made to determine the number of cases of pneumonia in which the influenza bacillus had been isolated from the consolidated areas. There were seventy-three cases of acute broncho or lobular pneumonia recorded; from these the influenza bacillus was isolated five times; twenty-three cases of acute croupus or lobar pneumonia. In only one case was the influenza bacillus recorded as having been found in this series. Here the pneumococcus was the evident cause of the pneumonia; the influenza bacilli were but secondary invaders. Being desirous of ascertaining if those six cases of pneumonia from which the influenza bacillus had been isolated resembled one another in any particular, clinically, macroscopically, or microscopically, a careful analysis was made of all of these cases.

CASE I. — Male, fifty years of age. Two weeks before entrance, chill, pain referred to umbilicus, cough dry at first, sputum never rusty, greenish, no shortness of breath, headache, malaise first few days. Temperature on entrance 102.4; pulse 110; respiration 30.

Physical signs. — Dulness over both bases, on right back dulness to spine of scapula with diminished fremitus and respiratory murmur. Left back, dulness with increased fremitus, broncho-vesicular respiration; above area of consolidation fine, moist rales. A few fine and coarse moist rales anteriorly. Urine passed involuntarily, acid ⅙ per cent. albumen. Leucocytes 9400. March 16, 1897, extreme dyspnœa; on the seventeenth, sudden death.

Autopsy. — Anatomical diagnosis: acute lobar pneumonia in stage of gray hepatization, inferior lobe left lung; sub-acute and chronic pleuritis; acute degeneration and arterio-sclerotic atrophy of the kidney; chronic perihepa-

titis and perisplenitis; arterio-sclerosis of aorta; senile degeneration of prostate.

Cover glass preparations from the exudate of the consolidated areas showed, upon examination, a moderate number of paired, lancet-shaped cocci, frequently with a clear staining space about them, *i.e.*, pneumococci.

Cultures from the consolidated area upon blood serum. Pneumococci and colonies made up of small polar-staining bacilli, like influenza bacilli.[1] These bacilli were isolated on blood agar slants. They did not grow upon plain agar or sugar agar.

Upon blood agar they grew as microscopic-sized, watery, clear colonies, showing little or no granulation under low power.

These bacilli were both short and long, with rounded ends, bi-polar staining; occasionally thread-like. By far the majority of these were of the small form. The bacilli did not stain by Gram.

Macroscopic appearance of lungs. — Right lung contains small amount of fluid; somewhat injected; a few fibrous indurations beneath pleura. Left lung, entire lower lobe voluminous, heavy, not collapsed; pleura covered with a thin membrane, which may be stripped off, containing minute vessels; on section, entire lobe homogeneously consolidated; surface gray, granular, moderately dry, hard to touch; excised piece sinks in water; superior lobe contains considerable fluid; somewhat injected; bronchi contain yellow muco-purulent material.

Microscopic appearance. — Examination of sections hardened in alcohol and stained with polychrome blue and eosine showed the alveoli filled with an exudate of leucocytes with considerable fibrin and a few red blood corpuscles; bronchi filled with leucocytes; pneumococci were demonstrated within the leucocytes in the exudate and in the bronchi; no influenza bacilli could

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[1] Frequently sufficient blood is carried over on the platinum loop with the culture from the lung to furnish an adequate amount of hæmoglobin for a weak growth of the influenza bacillus upon blood-serum tubes.

be demonstrated in these sections. The failure to find the influenza bacilli in sections may have been due to the small number present, or to degenerative changes in them, or to the imperfection of the preparation, or to the fact that they were only present in the bronchial secretion, so that they escaped observation. The pneumonia is regarded as due to the infection with the pneumococcus. The infection with the influenza bacillus is considered to be a secondary affair. Spleen small, pulp red, soft; capsule wrinkled.

CASE II. — Male, middle age. Brought into the accident room unconscious; found near railroad track five minutes after last train had passed; was known to have been drinking heavily for past two or three months; spent night in station-house; upon admission to accident-room next day, temperature 104.8, a few rales over both chests . . . death next day; temperature 110.

Autopsy. — Anatomical diagnosis: multiple cerebral hæmorrhages; broncho-pneumonia; congestion and œdema of lungs; contusion of head; hæmorrhage into right temporal muscle; slight meningeal' hæmorrhage; excoriation of skin of thorax, abdomen, and scrotum.

Cultures. — Bronchi. An abundant, moist, colorless growth, among which are pneumococci and small bi-polar staining bacilli. These could not be isolated. Lung, left inferior lobe: an abundant, moist, translucent growth made up of very minute, more or less confluent, colonies. Microscopical examination showed them to be pneumococci and small bacilli. These bacilli were isolated in pure cultures on blood agar. They did not grow on plain agar or sugar agar.

Macroscopic appearance of lung. — Right lung: superior and middle lobes not remarkable. Inferior lobe dark, filled with considerable dark blood and thin fluid which exudes from cut surface. Left lung: superior lobe not remarkable. Inferior lobe contains much black blood, and throughout greater part of it indefinite, apparently consolidated areas may be felt. The bronchi of left lung are somewhat injected and contain a slight amount of muco-purulent material. No adhesions present in either lung.

Microscopic appearance. — Examination of sections of the lung showed foci of variable size, in which the alveoli are filled with leucocytes; there was extensive desquamation of alveoli epithelium and engorgement of capillaries, with some extensive collapse of air cells. Little or no fibrin was present. Paraffine sections stained with methylene blue and eosine showed moderate numbers of minute bacilli within the leucocytes in the alveoli exudate.

Spleen not remarkable.

CASE III. — Female, fifty-three years of age. Entered Massachusetts General Hospital Feb. 15, 1897, for stomach trouble. Her chief symptom was extreme nausea. Examination of chest on entrance showed a few moist rales on right base behind. No dulness. No modification of voice sounds. Heart rapid and irregular. . . . On the 16th signs of beginning consolidation of left upper chest appeared. She became restless, noisy, grew rapidly delirious, temperature went up, and, failing rapidly, she died two days after entrance.

Autopsy. — Anatomical diagnosis: extensive bronchopneumonia; acute bronchitis and acute pleuritis; arteriosclerosis; atheroma of aorta; hypertrophy with dilatation of left ventricle; arterio-sclerotic atrophy of kidney; fibroid induration of both apices with bronchiectasis of left apex; old pleural adhesions left lung; corset liver; slight hypertrophy and dilatation of bladder.

Cultures. — Pleura: moderate number of pneumococci. Left lower lobe: a moderate number of colonies of pneumococci. Right lower lobe: many numerous minute colonies made up of short, round ended polar staining bacilli. Also a few colonies of pneumococci. The bacilli were isolated in pure cultures on blood agar after the method of Pfeiffer. After eighteen to twenty-four hours minute, translucent, water clear colonies appeared upon blood agar tubes at a temperature of 37.5 Centigrade, with little tendency to become confluent. Best observed with hand lens. No growth on plain agar. No growth on blood serum. Decolorized by Gram's method. Inoculation into guinea pigs and rabbits

showed no especial infective properties.   Intradural inocula-
tion, trepanation in rabbits in one instance produced toxic
nervous symptoms with marked rise of temperature.   The
effect of trauma alone, however, could not be eliminated.

Macroscopic appearance. — Right lung: on pleura poste-
rior portion a thin gray, yellowish fibrinous layer; lungs
large, voluminous; greater part of the lung tissue boggy, pit-
ting on pressure.   Air cells dilated, pale.   Superior lobe, an
area of fibroid induration near anterior margin.   A gray-
ish, finely granular area of consolidation about the size of a
pigeon's egg.   Middle lobe contains much frothy fluid.
Inferior lobe, greater portion, especially posteriorly and in-
feriorly, heavy, dense; on section of a finely granular, brown-
red appearance.   Left lung: superior lobe, along inferior
and posterior margin indefinite, gray-red consolidated areas.
Inferior lobe, almost entire lobe fairly homogeneously con-
solidated, especially the posterior and inferior portions.
Upon section red to slightly gray in color, finely granular,
containing considerable dark blood.   Bronchi of both lungs
show injection of mucous membrane and are bathed in muco-
purulent fluid.

Microscopic appearance. — In two sections all the alveoli
homogeneously filled with an exudate consisting largely of
leucocytes with a small amount of fibrin.   In two or three
other sections the filling up of alveoli is not so extensive, and
of variable extent in different sections.   There is the same
kind of exudate in all, chiefly leucocytes with marked scarcity
of fibrin.   The process resembles in some sections a.lobar
pneumonia; in others a lobular or focal pneumonia.   Bronchi
are filled with leucocytes in many of the sections.   The lining
epithelium of the bronchi is denuded and may be seen in the
detritus in the bronchial exudate.   The capillaries are in-
jected.   No satisfactory demonstration of bacteria in the
exudate could be obtained either by Weigert's method or
Pfeiffer's fuchsine method.   Attention was especially directed
to staining for the influenza bacilli, but with negative results.

CASE IV. — Female, thirty-five.   Entered Massachusetts
General Hospital May 15, 1897.   Exploratory laparotomy;

pneumonia developed; death three days later. Symptoms: pain in left lower chest, without chill; cough, extreme dyspnœa. No record of chest examination made.

Autopsy. — Anatomical diagnosis: extensive lobular pneumonia; cancer of right ovary, with slight extension into right innominate bone and constriction of right ureter; consequent hydronephrosis of right kidney; acute degeneration of right kidney, with chronic, passive congestion; salpingitis; laparotomy wound; slight circumscribed peritonitis.

Cultures. — Right lung: numerous colonies, largely confluent, colorless. These consist of several kinds of bacteria, among them a small bacillus like the bacillus of influenza. The colonies of the organism are very minute and rather numerous in places. A few pneumococci and streptococci also present in the cultures. The small bacilli grew on blood agar in the form of minute, colorless, water clear colonies of microscopic size. These bacilli had rounded ends, varied somewhat in size, especially as to length, some long forms being noted. After forty-eight hours the bacilli show marked irregularity in staining, especially in form of polar staining. Not so marked in twenty-four-hour cultures.

No growth on plain agar. No growth on sugar agar. Bacilli decolorize by Gram.

Macroscopic appearance. — Right lung: voluminous, pleura posteriorly, especially between the lobes, show small, scattered, rather numerous, bright red points. On pleura of anterior portion of median lobe a grayish fibrinous exudate. Superior and median lobes, heavy, voluminous. Scattered throughout the tissue are numerous ill-defined, discrete, and confluent resistant areas. These are grayish, slightly projecting, granular, rather sharply defined, varying in size from pea to chestnut, apparently limited by margin of lobules. In inferior lobe, immediately beneath pleura, are two pea to chestnut sized projecting tumor-like nodules, situated one at inferior margin of lobe, the other posteriorly or laterally. The pleura over these shows a fibrinous exudate. On section these nodules are yellow, opaque, granular, sharply defined in outline from surrounding lung, the one rounded, the other

irregular, and both projecting above cut surface. On pressure drops of yellow pus exude. They are resistant to touch. The tissue of the lobe seems to be infiltrated elsewhere with a thick, cloudy, reddish-gray fluid, and presents numerous discrete and confluent, grayish, granular areas of consolidation. Left lung: in inferior lobe numerous disseminated resistant areas of variable size, which on section are generally grayish, slightly projecting, granular, sharply defined, often apparently limited by the margin of a lobule. The lung tissue between is dark red, moist, resistant. On pressure, a frothy fluid exudes. The bronchi are injected and contain a frothy muco-purulent fluid.

Microscopic appearance of sections of the lung. — The capillaries are engorged with fluid. Alveoli filled with exudate, consisting chiefly of polynuclear leucocytes, some desquamated alveolar cells, and a few red blood corpuscles. The bronchi are filled with leucocytes. The epithelial lining in many is destroyed. No fibrin is present in the exudate. In places the alveolar walls are broken, leaving simply collections of leucocytes. Alcohol hardened preparation, stained with polychrome blue and eosine, show many of the leucocytes in the exudate filled with minute bacilli. Preparation stained by Gram and then by Bismarc brown show these bacilli to be numerous, both in the alveolar exudate and in the bronchi within the leucocytes.

Spleen weight, 180 grams, 12½ by 9 cm.

CASE V. — Male, sixty-two years of age. Entered Massachusetts General Hospital for cancer of stomach. At time of entrance record shows heart and lungs negative. Was in hospital two weeks, sitting up, when temperature began to rise gradually to 101, pulse 110. No record of any other symptoms. No evidence of anything wrong with the lungs. At end of five days, death.

Autopsy. — Anatomical diagnosis: carcinoma ventriculi, with metastases in neighboring lymph glands and liver; stenosis of pylorus; broncho-pneumonia of inferior lobe of left lung; purulent bronchitis; slight arterio-sclerosis; senile degeneration of prostate; mollusca fibrosa of skin of trunk.

Cultures. — Blood serum; several unknown organisms; no pneumococci; blood agar culture (dilution) rather numerous, minute, transparent colonies, like bacillus of influenza. There are also some larger, whitish, translucent colonies of an unknown organism. These minute, colorless colonies were composed of short bacilli with rounded ends and faintly staining centres. They vary in length somewhat. They do not grow on plain agar nor on sugar agar. They are decolorized by Gram. Direct examination of pus from the bronchi shows leucocytes containing many minute bacilli.

Macroscopic appearance. — In inferior lobe of left lung are scattered moderate numbers of resistant areas, pea to bean sized, which on section are grayish red, granular, ill-defined. The remainder of the lung is not remarkable.

Examination of paraffine section of alcohol hardened tissue, stained with polychrome blue and eosine, show over large and small areas the alveoli filled with leucocytes, a few blood corpuscles and desquamated cells. The capillaries are filled with blood. No fibrin could be seen.

Bronchi filled with pus corpuscles. Often the epithelial lining is destroyed.

Sections stained by Gram and then with Bismarc brown show the leucocytes filled with minute bacilli. These are present in large numbers in most of the leucocytes, both in the alveolar exudate and in the bronchi. No other organisms could be found.

The spleen is not enlarged.

CASE VI. — Male, sixty-five years of age. Entered Massachusetts General Hospital Jan. 2, 1899. Previous history: eleven days before entrance, malaise with sensation of heat; next day chills and fever; no sweating; began to cough; at first no expectoration, then profuse; never rusty, greenish. Pain first two or three days in back and legs. "Felt as though he had been beaten." Pain in sternal region upon deep inspiration.

Physical examination. — No dulness or bronchial elements detected in respiration. Snoring rales, particularly over both front and back. Some moist rales present also.

Examination next day showed consolidation on right apex; at evening, on right back. Examination of sputum reported by Dr. Musgrave: " Some organisms like pneumococci and some bacilli like influenza bacilli."

Death from cardiac failure on the ninth.

Autopsy. — Anatomical diagnosis: broncho-pneumonia; acute bronchitis; slight dilation of aorta and valves; cicatrix of trunk; slight arterio-sclerosis.

Cover-glass examination of exudate in lung shows many of the leucocytes filled with minute bacilli. These do not stain by Gram. Several paired lancet shaped cocci, *i.e.*, pneumococci, were seen in the same preparation, fewer in number than the influenza bacilli. In several of the leucocytes both organisms were present.

Cultures. — Inferior lobe, left lung: numerous small white colonies and some other colonies. Microscopical examination shows these to be cocci and tetrads.

Right lung, superior lobe: blood agar cultures after twenty-four hours in incubator show minute colorless colonies, which on examination with the microscope prove to be pneumococci and minute bacilli, polar staining, varying in length, and like influenza bacilli. After four days two tubes each show a number of small, grayish colonies and a small number of larger, more opaque colonies. These small colonies in one tube are less than 1 mm. in diameter, and for the most part consist of pneumococci and influenza bacilli. In the other tube there are probably forty or fifty colonies after four days. A few of these are large and opaque. The greater part, however, are small, — the largest about 1 mm. in diameter, — and are grayish and less opaque than the others. Under a low power these colonies have a slightly brownish colored centre, with an appearance of granules and globules and a translucent, colorless periphery. The margin is sharp and smooth or wavy in contour. The outline of the colonies is somewhat irregularly circular.

Microscopical examination shows bacilli like influenza bacilli, often showing a marked vacuolation or appearances of degeneration. A third tube developed a few colonies,

and among these some colonies of influenza-like bacilli.
The grayish appearance of the influenza colonies and their
comparatively large size may be due to the fact that they
were comparatively few in number and the blood agar was
dry.   Some of the smaller colonies are composed of other
organisms than pneumococcus and influenza bacillus.

Cover-glass examination of the bronchial secretion shows
numerous very small bacilli, mostly free, but some inside of
leucocytes.   They do not stain by Gram, and are considered
to be influenza bacilli.   From one of the cultures from the
lung the influenza bacillus was isolated, grew on blood agar,
as minute, colorless, transparent colonies, developing slowly,
attaining maximum growth after forty-eight hours or on the
second day.   Microscopic examination of these colonies
showed them to consist of small bacilli with rounded ends,
bi-polar staining or unstained in the centre, rather variable
in length; occasionally long forms, irregularly staining,
were seen.

There is no growth on plain agar, although a culture made
at the same time from the same culture on blood agar
showed influenza bacilli.   These bacilli do not stain by
Gram.

Macroscopical appearance. — Right lung, superior lobe :
resistant to touch.   On section the whole of the lobe seems
to be consolidated fairly homogeneously, but somewhat nod-
ular in places.   The appearance is grayish red and granular ;
mottled with spots of black pigmentation.   Inferior lobe :
nodular and resistant to touch.   On section numerous grayish,
red, consolidated, ill-defined, pea-sized areas of consolidation
may be seen, together with considerable black pigmentation.
Foci of consolidation are scattered throughout the lung.
Left lung : in inferior lobe near base the lung tissue over
an area about the size of an hen's egg is indefinitely nodular
and resistant to touch.   Near this area the pleura is grayish-
red, somewhat granular.   Bronchi of both lungs contained
much muco-purulent secretion, and were injected.   Spleen
small ; weight 92 grams.

Microscopical appearance. — Tissue hardened in Zenker's

fluid.   Paraffine sections stained with polychrome blue and eosine ; aniline oil gentian violet and a one per cent. aqueous solution of aurantia or carbol fuchsine and aurantia show the alveolar spaces filled with leucocytes, a few red blood corpuscles, and alveolar epithelium.   Bronchi filled with leucocytes. Epithelial lining in many places denuded.   Very little fibrin seen in the exudates of any of the sections.   Capillaries engorged.   Many of the leucocytes contain minute bacilli in large numbers.· Sections stained by Gram's method and then by Bismarc brown showed these bacilli to be much more numerous than the pneumococci in the sections, although some of the leucocytes contained both organisms.

Clinically. — An analysis of the clinical records enables us to draw the following conclusions: All of the six cases were past middle life and were suffering either from degenerative changes in the arteries or from malignant disease. In a majority of the cases there was no sudden onset of acute symptoms, as chill, rapid rise of temperature, etc.   With the exception of Case II., which was complicated with a head injury, the temperature rose gradually and was of moderate degree, with slight variation in pulse and respiration.

In a majority of the cases, beyond the presence of moderate fever, slight variation in pulse and respiration, and the presence of a few fine, moist rales sharply circumscribed, the foci of consolidation gave little evidence of their presence. In one case where several foci were fused together, dulness with slight change in voice sounds was observed.

In no case was rusty sputum observed. Both pneumococci and influenza bacilli were noted in the sputum during life in one case.

The leucocyte count in one case was as follows :

On the 3d	.	.	.	.	.	33,600
On the 5th	.	.	.	.	.	37,000
On the 6th	.	.	.	.	.	33,900
On the 8th	.	.	.	.	.	20,400

In one case the chlorides were reported to be diminished in the urine.

Bacteriologically. Culture Method.— The cultures were made upon slant agar tubes upon which a few drops of blood taken from the ear or finger, previously thoroughly cleansed, were smeared. Cultures were made upon slant agar and blood serum. The colonies of influenza bacilli appear upon the blood agar tubes in eighteen to thirty-six hours. In most instances the colonies are extremely small, transparent, water clear, circular in outline. They do not grow upon blood serum or plain agar tubes. A dryness of the surface of the blood agar and media seems to favor the growth of the colonies. On this account it has been found desirable to use for culture purposes agar slants which are not freshly prepared. The occurrence of long threadlike forms showing irregular, distributed, unstained spaces is a characteristic peculiarity of influenza bacillus in cultures. The prevailing form as seen in cultures is a small, short, plump, round-ended, polar-staining bacillus. Between this short form and the long form all grades of transition occur. The irregularity of staining and the occurrence of unstained spaces in the organism seem to be dependent, to some extent at least, upon the age of the culture, and are regarded as the result of degenerative changes of the bacilli. The vitality of the organism in these cultures has been found to be variable, but in general it may be said that transplantation fails to develop growth when the colonies from which they are taken are more than three days old.

TABLE I.

I.	Influenza bacilli.	Pneumococci.	
II.	Influenza bacilli.	Pneumococci.	
III.	Influenza bacilli.	Pneumococci.	
IV.	Influenza bacilli.	Pneumococci.	Streptococci and unknown organisms.
V.	Influenza bacilli.	....	Unknown organisms.
VI.	Influenza bacilli.	Pneumococci.	

From the table it may be seen that in no case was the influenza bacillus alone present in the cultures. In five out

of the six cases it was associated with the pneumococcus, once with pneumococcus, streptococcus, and unknown organisms; and once no pneumococci were found, but unknown organisms were present with the bacillus.

Recent investigations upon the etiology of acute bronchopneumonia have shown that in those cases not associated with acute infectious diseases usually the pneumococcus is the etiological factor. Its frequency in the causes of this disease would explain its presence where the infection was mixed. According to Pfeiffer, in those cases of influenza associated with pneumonia occurring in young healthy adults where death is at the height of the disease, the influenza bacilli may be isolated in pure culture from the pneumonic foci. The series of cases here reported do not come under Pfeiffer's classification, neither as regards age of the patients nor the association at the time with the severe attack of influenza. Recently Finkler has shown that influenza bacilli may be found in the bronchi for months after the acute symptoms of influenza have passed away. Extension into the bronchioles and alveoli, either alone or with the pneumococcus, results in broncho-pneumonia.

Pathological Anatomy.—Fraenkel has said that macroscopically an influenza pneumonia could not be diagnosed. Careful analysis of the condition of the lungs in these cases would seem to confirm the observation. The surface of the lung is variously described as gray, brown, brownish-red, yellowish, granular, finely granular.

If we omit Case I., where the pneumococcus seems to have been the important factor in causing the pneumonia, all five cases were of the broncho or lobular type. The foci were multiple, often, however, fused together, resembling a lobar pneumonia, but upon careful examination distinct lobules, or groups of lobules, could be discovered not involved in the process. These foci of consolidation were frequently widely separated from each other, one focus being at the apex, another at the base.

TABLE II.

	RIGHT LUNG.			LEFT LUNG.	
	Upper Lobe.	Middle Lobe.	Lower Lobe.	Upper Lobe.	Lower Lobe.
I.	. . . .	. . . .	. . . .	. . . .	x
II.	. . . .	. . . .	. . . .	. . . .	xxxx
III.	x	. . . .	xxx	xxx	
IV.	xxx	xxx	xx	. . . .	xxx
V.	. . . .	. . . .	. . . .	. . . .	xxx
VI.	xxx	. . . .	xxx	. . . .	. x

From the examination of Table II. it may be seen that the left lower lobe was involved five out of the six times. This is in keeping with the observations of others. No reason, however, is assigned for its occurrence.

In one case four out of the five lobes showed foci of consolidation.

Pleurisy was present in three cases, once as an organized pleurisy, twice as a circumscribed, fibrinous exudate over underlying foci of consolidation. In one of the two cases where foci of consolidation were immediately beneath the pleura softening with abscess formation had occurred. This is important to note, for cases have been reported where in the course of an influenza pneumonia a sudden pneumothorax has developed. Mosler, Furbinger, and Kundrat have reported such cases.

In no case was gangrene of the lung or empyæma present in our series. Both of these conditions have been described in cases of influenza pneumonia by Fraenkel, Pfeiffer, Rhyner, and others.

In our series the bronchi were injected and filled with muco-purulent material in every case.

Contrary to the observation of Gmeiner, who says there is always swelling of the spleen present in these cases, in none of our cases was such enlargement found.

Histology. — All of these cases were characterized by an exudate into the alveolar spaces composed chiefly of leucocytes. In five out of the six cases there was a marked scarcity of fibrin present in the exudate. In one case where the entire lobe was affected, where pneumococci were found in large numbers in the exudate and in the leucocytes, a large amount of fibrin was noted to be present in the alveoli, together with leucocytes. This case has been spoken of and considered to have been caused by the pneumococcus, with a secondary infection with influenza bacilli.

In all, the capillaries were injected and the bronchi filled with leucocytes, and often destruction of the lining membrane of the bronchi had occurred.

Where the bacilli were present in the sections they were usually in large numbers filling up the leucocytes, both in the alveolar exudate and in the bronchi, while the pneumococci were relatively few.

Conclusions. — 1. Cases of pneumonia caused by the influenza bacillus may give few, if any, signs clinically of their presence beyond a moderate degree of fever, and a few fine, moist rales more or less circumscribed.

2. The influenza bacillus by itself is capable of producing pneumonia; however, the pneumococcus is frequently associated with the influenza bacillus in its production.

3. The type of the pneumonia is usually broncho or lobular, frequently consisting of multiple foci, with a tendency to involvement of the lower lobe of the left lung.

4. Upon microscopic examination the exudate is composed largely of cells, chiefly of leucocytes. The amount of fibrin present in the exudate is small. Bacilli usually are present in large numbers inside of the leucocytes, both in the alveolar spaces and in the bronchi.

PLATE I.
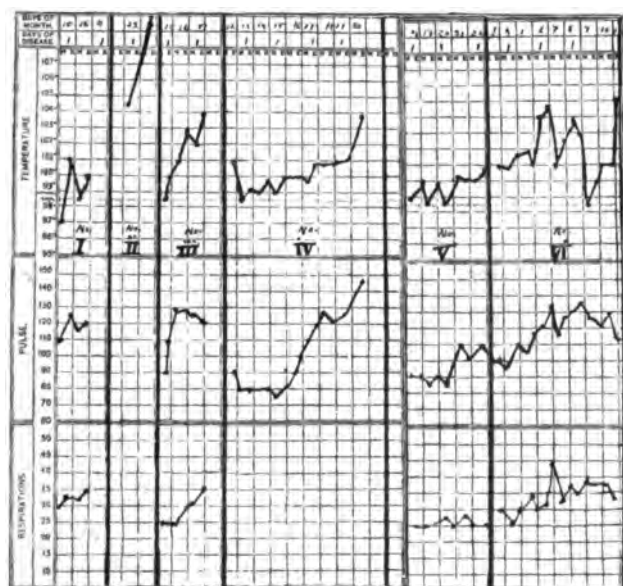
Temperature Charts from Six Cases of Pneumonia associated with
the Presence of the Influenza Bacillus.
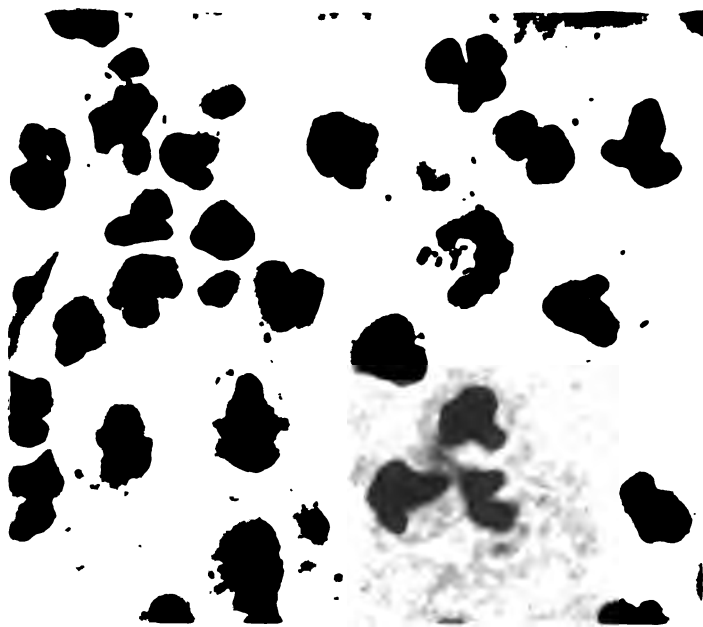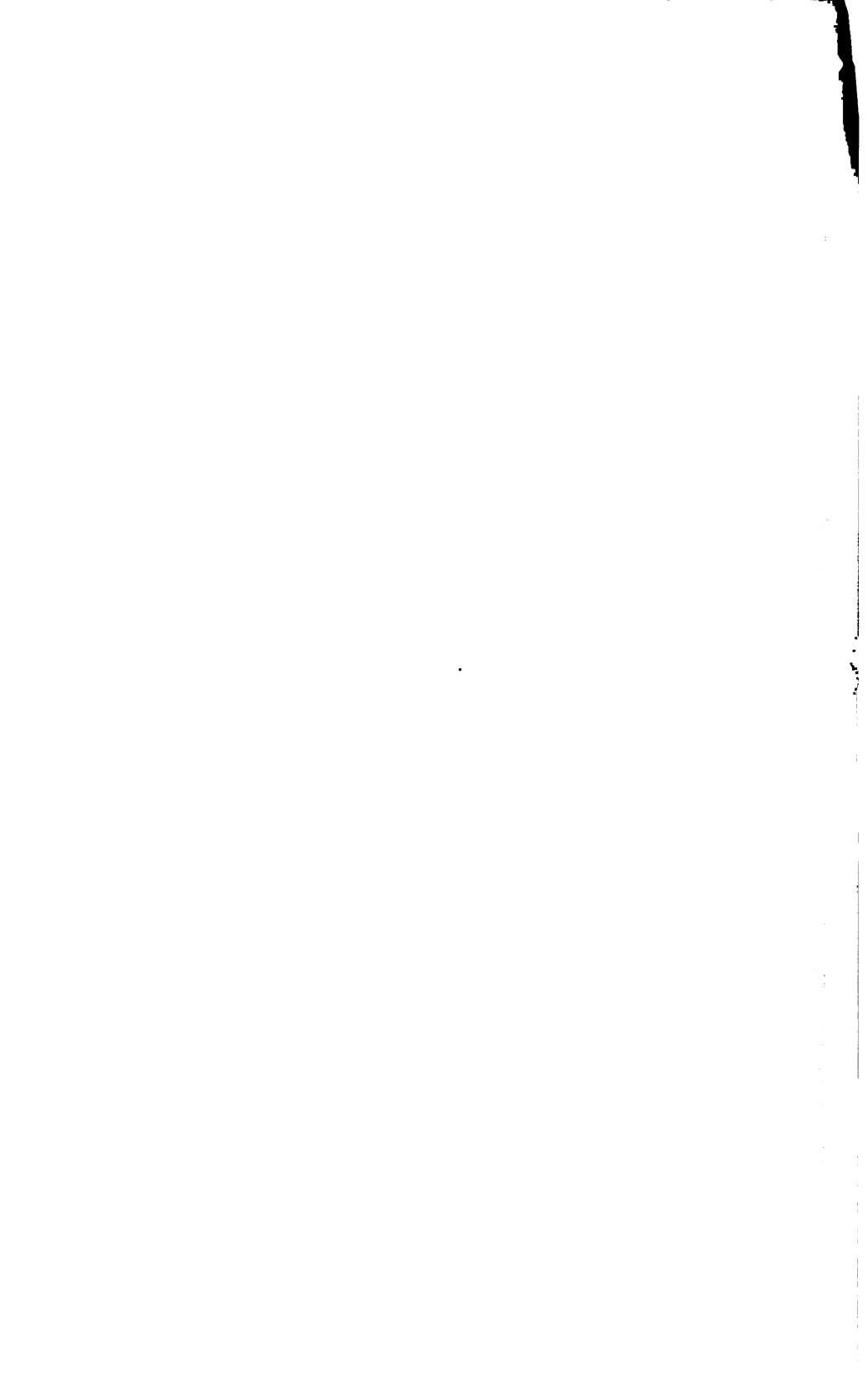
W. H. SMITH — THE INFLUENZA BACILLUS AND PNEUMONIA.

Fig 2.

Leucocytes from consolidated area.   One cell showing influenza bacilli
and Pneumoccus

Fig 3.

Leucocytes from consolidated area.   One cell filled with
influenza bacilli.

W H SMITH — THE INFLUENZA BACILLUS AND PNEUMONIA.

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[Editor's Note.— Plates to Dr. Smith's article will be furnished in the next number of the Journal.]

A STUDY OF THE JERKING OR TRIGGER KNEE.

FREDERICK J. COTTON, M.D.

This affection is referred to in the French literature as " genou à ressort," in the German as " schnellendes " or " federndes Knie," while it seems not to have been noticed in the English literature at all.   The disorder is a rare one, and consists of an irregularity in the motion of extension of the knee, — a sudden jerk forward at the end of the movement sharp enough to give a considerable jar and to be of much inconvenience to the patient.   It is not associated with any disease of the joint.

At the suggestion of Dr. E. H. Bradford the writer has looked up certain of these cases and attempted to explain the underlying difficulty.

In the literature but very few cases are recorded. Delorme (1), Tillaux (2), Thiem (3), Nasse (4), and Rölen (5) report cases.   Barth (6) also reports a case under this title, but it is atypical and does not really belong in the same class.   With this exception the clinical condition seems to have been always about the same.   Nasse describes it as a sudden movement forward of the lower leg and a jerk jarring the limb or the whole body, occurring when extension reaches an angle of about 160 degrees.

The clinical cases looked up in this study seem to belong definitely to the same type as those previously recorded. Unfortunately for the present investigation, however, some of them no longer show the characteristic jerk, and we must rely for this upon data of previous examinations.   To Drs. Bradford and Lovett I owe the privilege of using these older case-notes and of examining most of the patients.

In the first case examined the movement was precisely as above described : When extension reached 160 degrees there was a snap and jerk and the whole lower leg was suddenly carried into full extension.   At the same time there was a sudden outward rotation of the tibia.   On more careful examination the snap in the joint is readily and definitely

located on the outer side of the joint just above the head of
the tibia.   Here there is to be felt an unnatural prominence,
— a mass not sharply defined as to edge, about ¼ × ½ inch,
projecting perhaps ⅙ inch.   Its size corresponds to about
the middle of the external meniscus.   This mass is to be felt
only in flexion.   When extension reaches 160 degrees it
may be felt to slip forward and inward with a snap, coincid-
ing in time with the jerk of the leg.   It is then no longer to
be felt, but in flexion it slips back into its old place.   The
phenomena are repeated with each and every extension,
whether active or passive, whether the leg is bearing weight
or not, and are exaggerated by inward pressure at the knee;
pressure in the opposite direction does away with the whole
phenomenon.   Extension becomes normal so long as this
pressure continues.   Rotation of the leg with the knee at
right angles gives a simple joint snap.

In this case the trouble is of nearly five years' standing, fol-
lowing on a fall.   There has been much improvement, not
only in increased usefulness of the leg, but a decided lessen-
ing of the jerk as well.   The boy is now fifteen years old;
normal enough, save for poor muscular development and lax
ligaments in this knee.   There is a long ligamentum patellae
as shown by the X-ray.

In the second case, a young girl, the note in the Hospital
Records of four years ago reads: "Within twenty degrees of
extension of the knee the external semilunar cartilage slips
forward; on flexion of twenty degrees it disappears.   All
peculiarity is avoided by pressure on the internal condyle
during motion."   This case, then, had a marked snap and jerk
in extension.   She was treated with apparatus, but was lost
track of for some years.   When looked up she proved to
have no trouble save for inability to fully extend the knee,
and some pain when she overused the leg.   There was a
slight fulness to the outer side of the patella, evidently a
thickened lig. alarium of this side.   There was a slight snap
in extension, located at or near the site of this thickening, but
the changes here evidently do not represent the conditions
observed some years previously.

In the third case the record refers back to the case just cited, — "a case like A— S—." Here, too, there was a snap, referred by the reporter to the region of the external semilunar cartilage. At the time of this note the child was one and one-half years old. The trouble dated back to a comparatively slight trauma. When looked up this child, now a healthy little girl of five years, showed absolutely nothing abnormal about the knee, nor were there any abnormalities of the bones in general.

In the fourth case — an infant — there was at one time a marked snap and jerk similar to that described for the first case; but there has been gradual improvement, and now, after an interval of something over a year, this snap is gone and the knee seems entirely normal.

In another case (an adult whôse internal semilunar cartilage has frequently been displaced, and is obviously more or less loosened) was found the same slipping inward and forward of the external semilunar cartilage in extension as has been described. This slipping is accompanied by a snap, but there is no jerk of the leg. The ligaments of this knee are very lax.

In looking over these cases it seems fair to class them with the reported cases. The first two, perhaps the first three, seem to correspond exactly to the descriptions published.

The cause of jerking knee has never yet been satisfactorily explained. Delorme thought his case dependent on contraction of the hamstring muscles. Barth's case, an atypical one, showed clonic spasm of the quadriceps. Tillaux found no cause to explain his case, and was not even helped out by a joint dissection. Thiem and Rölen both assume a torn posterior crucial ligament, but give no conclusive reasons for the assumption. Nasse offers no explanation of the mechanics of the phenomena. All the reported cases date back to some trauma, often slight; in none is there accompanying joint disease.

In the clinical series here noted there is, beyond the lax ligaments and the loose mass which may be palpable externally, no direct evidence as to the condition, but the marked

effect on the abnormal motion of pressure inward and out-
ward at the knee negatives the idea of extensive bone changes.
In conjunction with the slipping felt at the outer side of the
joint this makes it probable that the semilunar cartilages are
involved rather than the bones themselves.

In a normal knee the movements of the cartilages are sim-
ple and limited. Flexion gives a movement backward of both
cartilages on the tibia, and there is a corresponding movement
forward during extension.   There is also a change of relation
due to the outward rotation of the tibia toward the close of
extension, — the external meniscus then slipping into the
shallow depression in the femoral surface which it occupies
in full extension.   This gives an additional forward move-
ment of the cartilage considered in its relation to the tibia.
In the normal knee all these movements are gradual and of
no great extent.

A number of experiments were made on dissected cada-
vera, the external cartilage being variously loosened, cut,
mutilated, artificially thickened, etc.   Suffice it to say that no
method of experiment save that to be detailed had any ap-
preciable effect on the movements of the cartilages during
simple flexion and extension.

When the coronary attachments of the cartilage were cut
away, however, leaving its end insertions intact, not only was
the range of movement of the cartilage in general somewhat
increased, but there was a modification in the movement as
well.   The movement backward in flexion took place as be-
fore, but the movement forward in extension began less
promptly, the cartilage lagging a bit behind the movement of
the tibia. .When the knee reached an angle of about 160
degrees there was a sudden movement forward of the loosened
cartilage as the tibia rotates outward, similar to the normal
movement, but of greater range and occurring suddenly.

If the cartilage is not only loosened, but also cut away
behind or cut across at any point behind its middle, this
motion does not change in character, but is a little increased
in range.   Apparently the mechanism is essentially that of
the normal movement, but the loosened cartilage moves more

freely, and owing to its retardation during the first part of extension traverses the last part of its course with a sudden jump. This motion depends in part on the drag of its anterior attachment, partly on a wedging forward of the cartilage between the oblique moving surfaces of the bones.

These experiments were repeated a number of times on different cadavers, and the abnormal movement of the loosened or cut cartilage reproduced itself almost constantly. In all cases pressure outward on the knee during motion diminished this movement markedly. No audible snap could be produced on the cadaver, however, nor was there any notable jerk in extension.

The correspondence of these experimental results with those seen clinically is not exact, but something must always be allowed for differing conditions in cadaver experiments, and the correspondence is close enough to make it highly probable that the movements in the two cases are the same.

In default of direct evidence this seems a fair assumption, for it is clear from the examination of cases that the external semilunar cartilage is involved in the abnormal movement, and the spontaneous recoveries noted make it highly probable that loosening of the cartilage rather than more extensive damage is the usual condition. Loosening of the semilunars may occur uncomplicated with other lesions, as is clear from cases of Langton (7), and Robson (8), and from certain experiments by Honigschmied (9).

No other explanation offered seems probable. If there were changes in bony surface lateral pressure outward at the knee would not abolish the peculiar motion; but in fact just this does result both clinically and experimentally as noted above. The theory of ruptured posterior crucial is not backed by any facts, and the results of such an injury would not disappear with growth. Moreover, cutting the posterior crucial experimentally failed, in the writer's hands, to give any like result.

It may be concluded, then, that the trigger-knee is dependent on interference with normal extension by a damaged external semilunar cartilage, perhaps thickened or perma-

nently displaced in some cases, loosened in all, and that this occurs in knees with lax ligaments; apparently always following some trauma, usually with some synovitis.

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SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on June 6 and 20, at the Harvard Medical School, at 8 P.M.
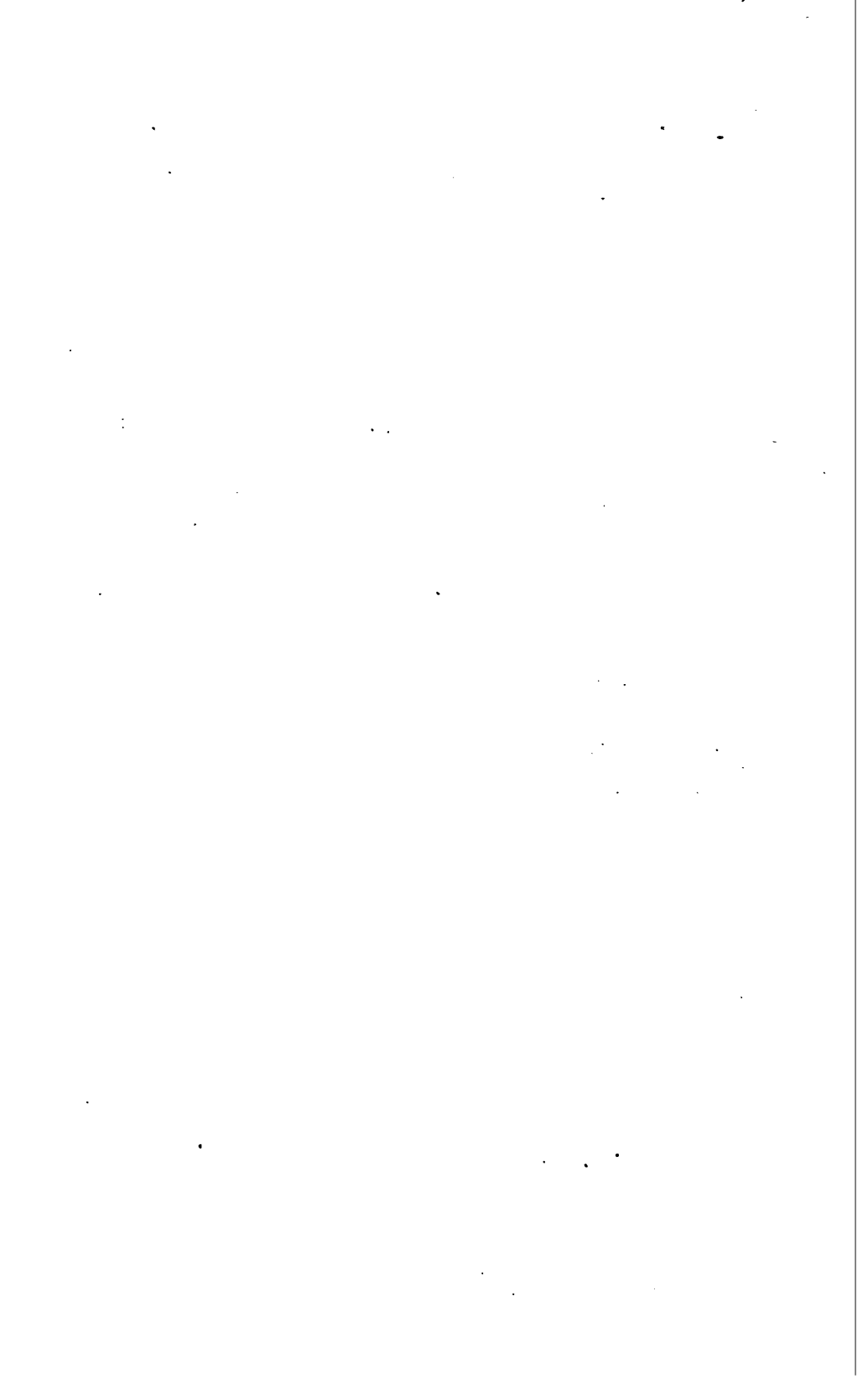
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JOURNAL

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CONTENTS.

"COLOR SCREENS" AS APPLIED TO PHOTOMICROGRAPHY.

J. G. HUBBARD.

In the improvement that has been made in the last few years in photomicrography, color screens, used in connection with ortho-chromatic plates, have been probably the most important factor, and in the future they will be undoubtedly of still greater importance.   But it is only with the correct use of color screens that this improvement will come.

I quote from a well-known authority: "Experience alone can teach us how best to choose a suitable plate and suitable screen for each subject."   This way of approaching the subject is radically wrong, for by the empirical use of screens the improvement must be very slow, and by this means we probably should never arrive at the full value that they are capable of giving us.

Let us attack this problem in another way.   We have color screens which we interpose between the source of light and our subject.   Now, the only effect that they can have is to modify the light.   Let us analyze this light.   If we turn to the spectroscope we at once find the key that places us in a position to use the screens with definite knowledge as to our results.   To illustrate this I will take

the example of an object stained with fuchsin, in a clear
field, mounted on a slide. Examining the fuchsin dye with
the spectroscope, we find that it has selective absorp-
tion; that is, that it stops nearly all the green light from
passing through, but not the red and blue. To illustrate
this, let us refer to the diagram, Fig. 1, which is a represen-
tation of the absorption of the fuchsin dye. We see from
this that the light which the fuchsin-stained object allows to
pass through is the lower part of the spectrum (red and
orange) and the upper part of the spectrum (blue and vio-
let). Now, in future we shall not use any color term, but
simply refer to our analyzed light by its position in the
spectrum, or, in other words, by its wave lengths, and not by
its color, as its position is the only factor which is of impor-
tance to us.

Taking Fig. 1, which represents the whole spectrum or
white light, separated by the spectroscope into its various
wave lengths, and dividing it into three parts, a, b, and c, b
representing the portion which is absorbed or stopped by
the fuchsin-stained object. Considering now Fig. 3, 1 rep-
resents the source of light, 2 the slide with fuchsin-stained
object, 3 the objective or projecting lens, 4 the image as
projected on a sensitive plate.

The white light coming from the source 1 passes
through the clear field of the slide 6 and is projected on
to the clear field of the image at 8, and its effect upon the
plate may be represented as the effect of the total spectrum,
$i.e.$, $a + b + c$. On the other hand, the light starting from
the source 1, arriving at the fuchsin-stained object, has that
portion represented by b absorbed or stopped by the fuchsin
dye, while a and c pass through the fuchsin to form the im-
age of the fuchsin-stained object which affects the sensitive
plate 9.

Representing by the curve X the approximate relative
effect of the various regions of the spectrum upon the sensi-
tive plate, we will give, according to this curve, rough nu-
merical values to a, b, and c, assigning to a the value of 10,
to b 20, to c 30. Substituting these numerical values for the

letters, we have for the total effect of all of the light of the spectrum upon the clear field $a + b + c = 10 + 20 + 30 = 60$, and for the effect of the light which the fuchsin-stained object allows to pass $a + c$, or $10 + 30 = 40$.   So that our proportionate effect upon the sensitive plate of the light which passes through the fuchsin-stained object as

Fig. 1

Fig. 2

Fig. 3
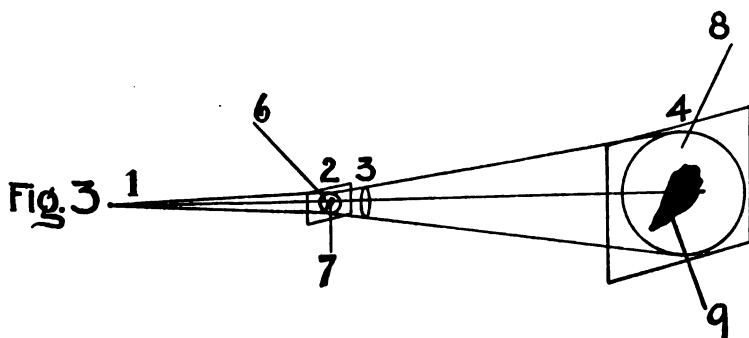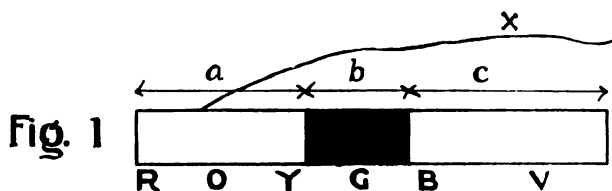
compared with that which passes through the clear field is as 40 : 60.

In most photomicrographic work, especially with high powers, the main difficulty to overcome is to increase contrast.   We may accomplish this by using a screen, or system of screens (see Fig. 2), in which we have absorbed or cut off all the light of the spectrum which we have previously represented by a (Fig. 1), and also that represented by c (Fig. 1).

Now let us interpose this screen between the source of light (1, Fig. 3) and our object (2, Fig. 3).

The light starting from its source (1, Fig. 3), arriving at our screen, is deprived of *a* and *c*, but allows *b* to pass through. Now *b*, arriving at the clear field of our slide, passes through and is projected on to the field of our image (8, Fig. 3), and affects the sensitive plate with its previously given numerical value of 20, but when it arrives at our fuchsin-stained object it is absorbed or stopped by the fuchsin dye, and no light goes to form the image which affects our sensitive plate. Now let us place these figures as a proportion, the same as we did in a previous example; we then have the proportion 20 : 0, or the greatest contrast.

We have assumed in this analysis that our screens are theoretically correct and also that our numerical values given to our curve are correct. Of course this is not absolutely true, but what variation there is from the truth will simply modify results quantitatively, not qualitatively.[1]

Next let us take the reverse of this problem, *viz.*, the fuchsin-stained object being one heavily stained, but having detail which we wish to bring out. For this we require less contrast. How can we arrive at the least contrast by screening? We can at once assume that the exact opposite of our previous screening will be the one to analyze. We will take a screen which has the same absorption as fuchsin — or, we might say, a fuchsin-dyed screen. Placing this between our source of light (1, Fig. 3) and our slide (2, Fig. 3), we stop all the light of the spectrum represented by *b* (Fig. 1) and allow *a* and *c* to pass through; *a* and *c*, arriving at the clear field of our slide (2, Fig. 3), pass through, go to the field of our image affecting our sensitive plate (4, Fig. 3), and are represented by $a + c$ or $10 + 30 = 40$. Again, *a* and *c* passing through our screen, arriving at our slide (2, Fig. 3), are not stopped by the fuchsin-dyed object, and go on to form the image of the fuchsin-dyed object, and can be represented by $a + c = 40$. Our proportions are now equal and this gives us the least contrast, or no difference of effect on the sensitive plate. This is, of course, as before, assuming the screens

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[1] The numerical values given are simply to represent approximate proportions and are not definite values.

theoretically perfect, and is given simply to illustrate the principle. What is true of this principle is true of the practice with slight modification.

What we can do with fuchsin-stained objects we can do with almost any other dyes. But to use the screens to the best advantage we must analyze the stain and the screen with the spectroscope, and apply the knowledge so obtained rationally and not empirically. Until this is done the advancement in the use of screens will be small.

EXAMPLES OF THE APPLICATION OF "COLOR SCREENS"
TO PHOTOMICROGRAPHY.

JAMES H. WRIGHT, M.D.

(*From the Laboratory of the Massachusetts General Hospital.*)

As illustrations of the application of the principles set forth
in the paper of Mr. Hubbard, a number of lantern slides were
shown.   Of these lantern slides, those from three subjects are
here reproduced on Plates I., II., and III.

The first subject, which is illustrated by the Fig. 1 on Plate
I., is from a cover-glass preparation of sputum containing
tubercle bacilli, in which the bacilli were stained with fuchsin
and the nuclei of leucocytes with methylene blue.   The mag-
nification is approximately 1400 diameters.   The problem
here, as in photomicrography in general, is to make the
objects in the field of the objective intercept, or become
opaque to, a sufficient amount of actinic light-rays, so that
what is practically a sufficiently dense shadow of these objects
is cast upon the sensitive plate, for photomicrography is
essentially the photography of shadow images of varying
densities.

Proceeding now on the principles which have been pointed
out by Mr. Hubbard, we must first consider what are the
spectrum absorptions of the two aniline dyes with which we
have here to do.

Now, approximately stated, fuchsin absorbs chiefly the
green portion of the spectrum, and methylene blue absorbs the
yellow and upper red.   Thus these two dyes together absorb
nearly all of the median portion of the spectrum, but they
allow the most active of the spectrum rays, the blue, to pass
through them.   It is therefore evident that, with light rich in
blue rays, the " actinic " shadow cast by these objects would
not be the densest which it is possible to obtain.   Inasmuch
as we wish here to get the greatest possible shadow effect,
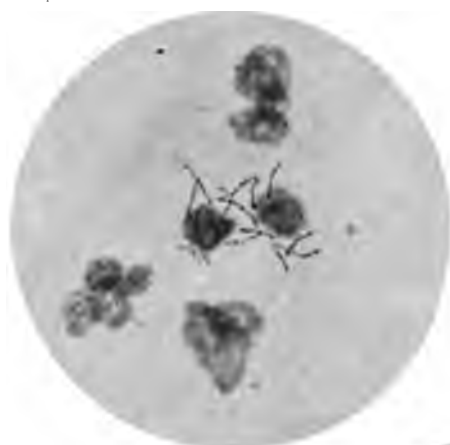or shadow density, from the bacilli and nuclei, we should,
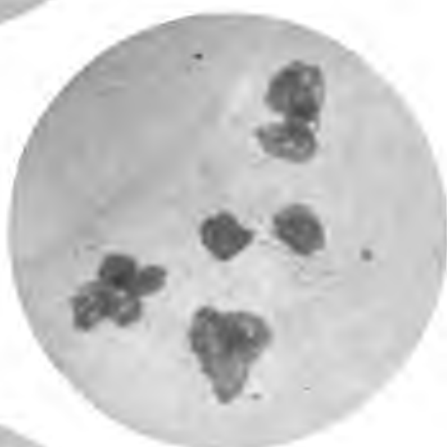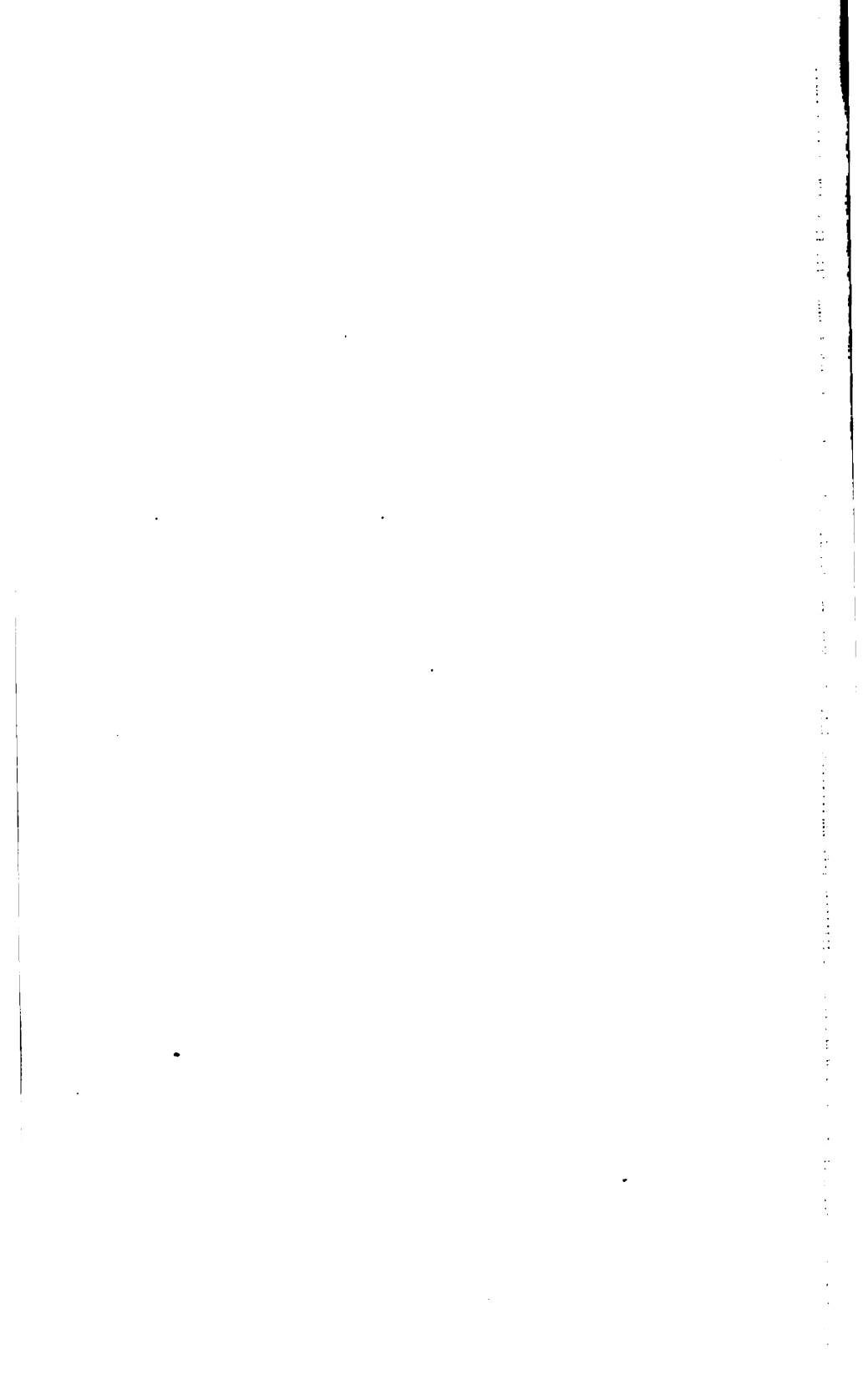following the principles of Mr. Hubbard's paper, cut off these
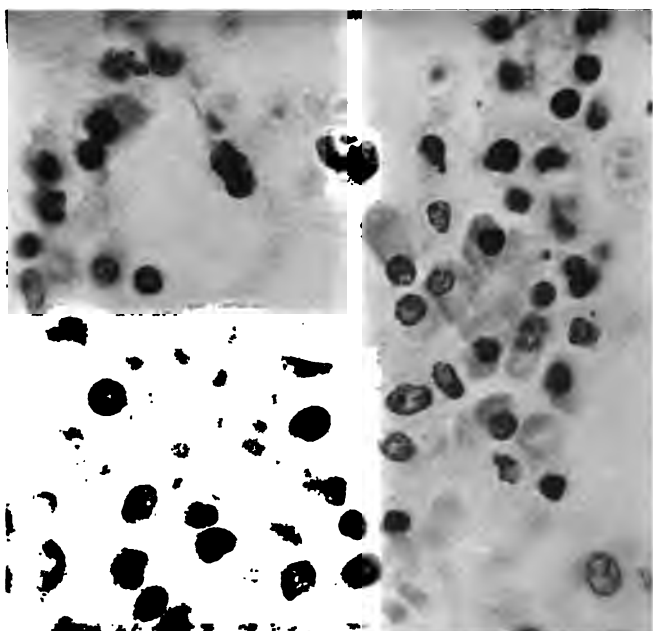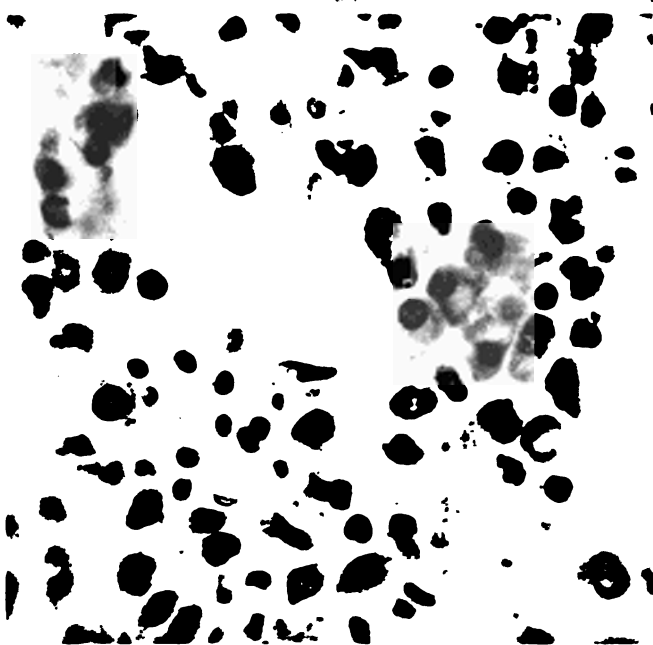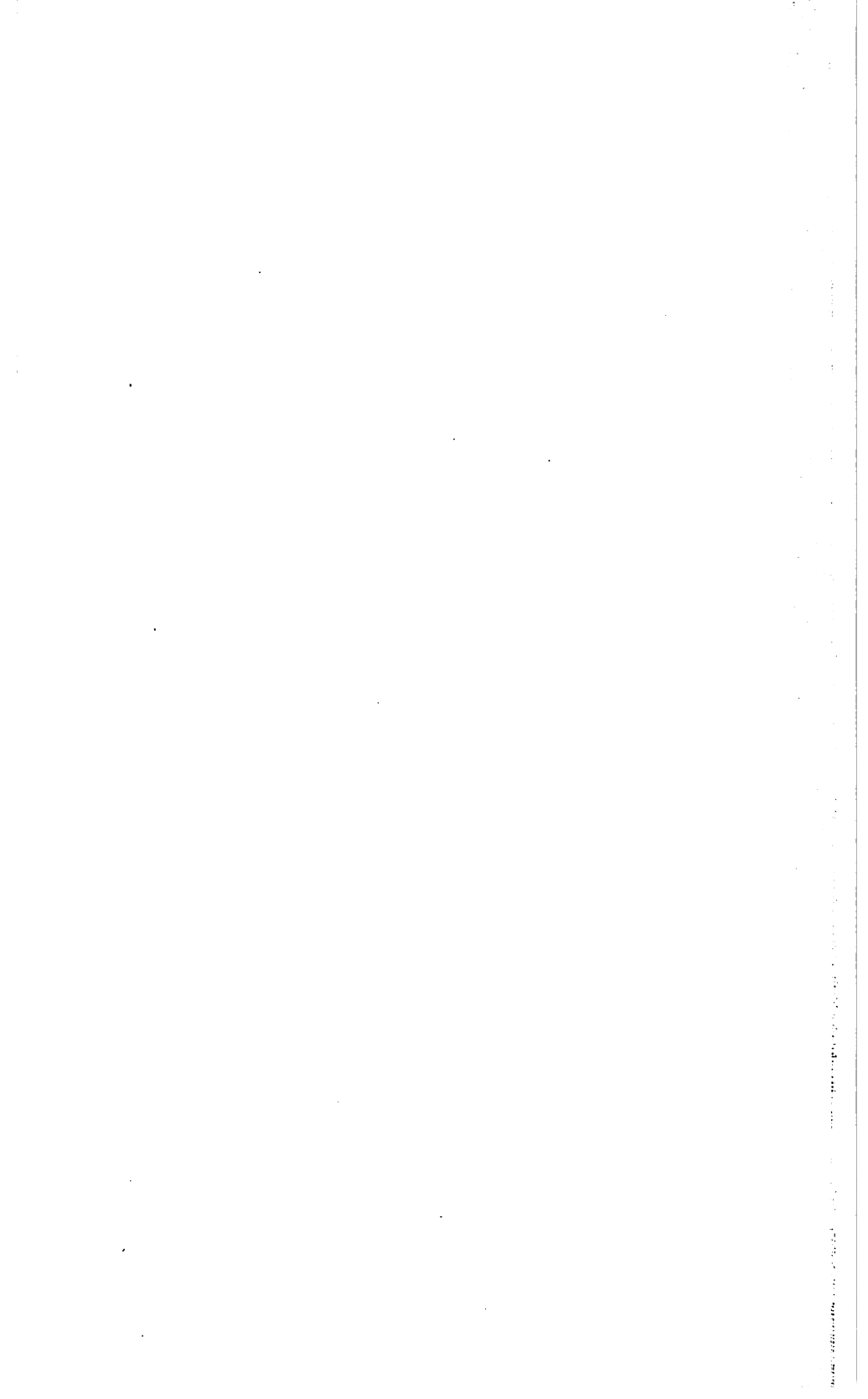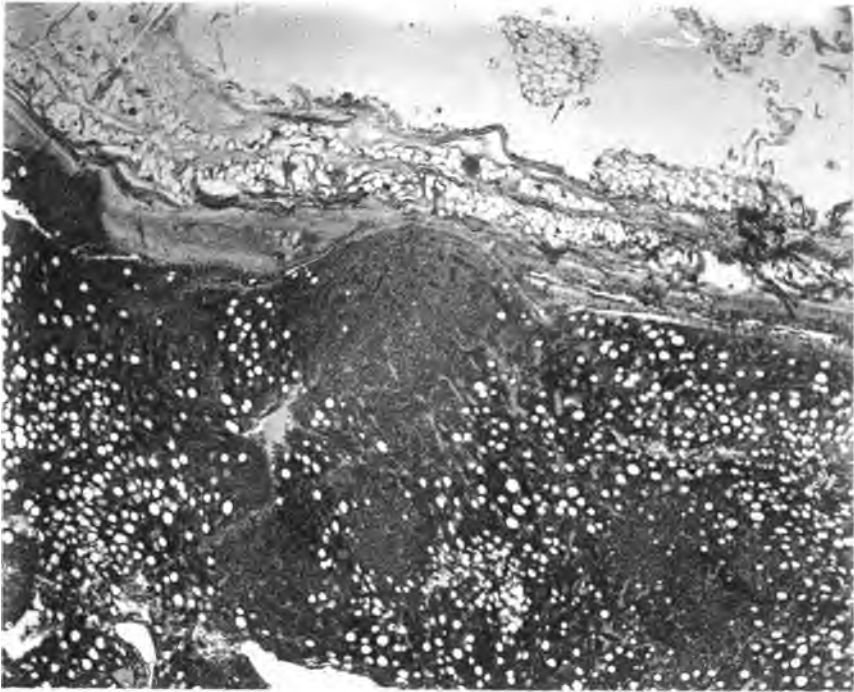
Fig 1.

Fig 2.

Fig 3.
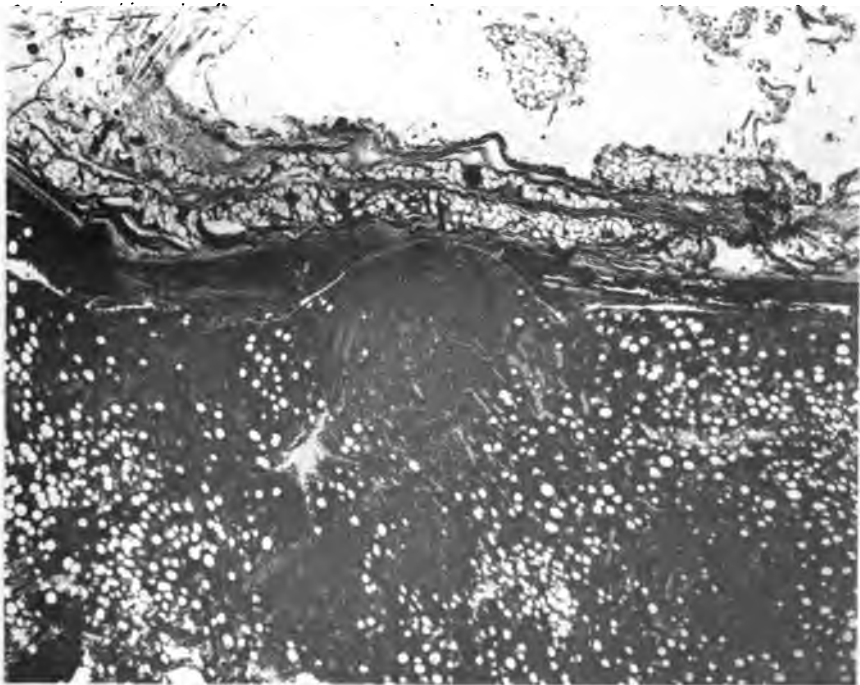
Fig 4.

Fig 5.

Fig 6.

Fig 7.

blue rays as well as the red rays which come below the
absorption of the methylene blue, and allow only the green
and yellow rays to enter the microscope.   Since, however,
the ordinary good ortho-chromatic plates are only slightly
sensitive to the red rays, it is sufficient, in practice, to obtain
this effect, to cut off the blue rays alone.   This is done by
passing the light through a solution of some substance which
absorbs the blue rays of the spectrum, before admitting it
to the microscope.   In the present instance we have used a
solution of picric acid, which has such a property in a marked
degree.

Figs. 2 and 3, Plate I., from the same subject as Fig. 1,
show the effect of filtering out those portions of the spectrum
of the illuminating light which are absorbed or cut off by the
aniline dyes with which the objects are stained, so that the
field becomes illuminated more or less exclusively by those
portions of the spectrum which the stained object allows to
pass.   Thus the difference between the amount of light acting
on the field and the amount intercepted by the object may
be much diminished, or rendered *nil*, theoretically.

Fig. 2 shows the effect of filtering the illuminating light
through a solution of fuchsin ; Fig. 3 the effect of filtering the
light through a solution of methylene blue.   In each case the
effect has been to diminish the relative opacity or shadow
density of the objects stained with the same dye as that in
the ray filter, or " color screen," so that the resulting image
is dim, and its contrast with the field is diminished.

It will be noted that in the case of Fig. 2 the strength of
the image of the blue-stained nuclei is not so great as in
Fig. 1.   This is due to the fact that the fuchsin filter
allowed the blue light of the spectrum to pass through it, and
since the blue light was not cut off by the methylene-blue
stain of the nuclei, and is of greater actinic value than the
green and yellow portions of the spectrum, the resulting
shadow cast by the blue-stained nuclei is not so actinically
dense as in the case where the picric-acid filter was alone
employed, although the absorption of the picric acid does
not extend down in the spectrum to the site of absorption by

the methylene blue. To get the greatest density or actinic shadow effect from methylene-blue-stained nuclei it would be necessary to filter out from the illuminating light all the actinic light of the spectrum from the blue end down to the point where the absorption by the methylene blue begins, which is in the yellow and upper red. For this purpose some solution of aniline dye or similar substance could be used which had such absorption, or a combination of dyes, such as fuchsin and picric acid, could be employed, the picric acid cutting off the blue rays and the fuchsin cutting off the rays which remain between the absorption of the methylene blue and that of the picric acid.

In Fig. 3 it will be also seen that the opacity of the fuchsin-stained bacilli is not so great as in Fig. 1. This may be explained on the grounds above stated; *viz.*, that since the methylene-blue ray filter allowed the green and blue rays to pass, and inasmuch as the fuchsin of the bacilli absorbed or stopped only the green rays and let the very actinic blue rays through along with the rest of the spectrum, the difference between the amount of actinic-light rays operating on the field and the amount of such rays intercepted by the fuchsin-stained bacilli was not so great as it would be if only the green light had been allowed to pass into the microscope. In other words, to get the greatest theoretical shadow effect from the bacilli it would be necessary to use for illumination only rays from that part of the spectrum which are absorbed or stopped by fuchsin, *i.e.*, rays from the green region of the spectrum. For this purpose we might use both methylene blue and picric acid together as ray filters — or any other combination of aniline dyes, or absorbent materials, which would allow only rays from the green region of the spectrum to pass through them.

It will be apparent from the foregoing and from the general theory as presented by Mr. Hubbard that, in order to get the greatest theoretical shadow effect from either the blue-stained nuclei or from the fuchsin-stained bacilli one or the other's shadow effect is of necessity diminished in so doing. Thus, if the green rays alone of the spectrum were

employed on the present subject to get the greatest shadow effect from the bacilli it is clear that the shadow effect of the blue-stained nuclei will be diminished, because the methylene blue of the nuclei does not interrupt the green rays.

Likewise in the case where we wish to get the greatest shadow effect from the blue nuclei, where only the yellow rays and weakly actinic red rays are allowed to enter the microscope, it is evident that the shadow effect of the fuchsin-stained bacilli will be diminished, because the fuchsin does not intercept the rays of this portion of the spectrum.

From the foregoing it follows that if we wish to get a shadow effect or photographic representation of both elements in the preparation we cannot obtain the densest shadow effect from both at the same time, but we must be content with a compromise. Thus Fig. 1 is a compromise, for we have removed only the blue rays of the spectrum by the picric-acid screen, while the actinic green light is still allowed to pass through the filter, and through the methylene blue of the nuclei, and likewise the yellow rays through the fuchsin. If, however, we cut out by ray filters either the green or the yellow rays in addition to the blue rays we should get again some such effect as is shown in Figs. 2 and 3, where in the one case we have the green rays cut out by the fuchsin filter and in the other the yellow and upper red rays cut out by the methylene-blue filter, with resulting dimness or diminished density in the shadow of one or the other element of the preparation.

Therefore the best we can do theoretically and practically is to work with the actinic yellow and green light of the spectrum together, by which we obtain a fairly dense shadow effect from both the methylene-blue and fuchsin-stained elements, without increasing the shadow density of the one at the expense of the other.

Figs. 4 and 5, Plate II., are from two negatives of the same subject, and they are designed to show the application of some of the foregoing principles to practical photographic work. The subject is a thin section of red bone-marrow, stained with fuchsin, and the magnification is approximately 950 diameters.

Fig. 5 is from a negative taken without any " color screen " or ray filter, all of the rays of the visible spectrum passing into the microscope. It will be noted that while the nuclei are very prominent and sharply contrasted with the field, yet that there is a lack of detail in the nuclei themselves. _In this case the fuchsin-stained nuclei have intercepted too great a proportion of the actinic rays as compared with those acting on the field, and it is desirable to diminish this proportion. The theory indicates that in this case it is necessary to diminish the density or opacity of the shadow effect produced by removing more or less of those rays from the illuminating light which are absorbed or stopped by the fuchsin. As has been pointed out by Mr. Hubbard, it is most convenient in this case to use a filter or screen composed of the same dye as that with which the object is stained, and this was done. Fig. 4 shows the effect upon the details of the nuclei produced by the application of this principle. It will be observed that the details of the nuclei are much more apparent than in Fig. 5.

Figs. 6 and 7, Plate III., are very low power photographs of a portion of a rib, showing a myelogenous tumor growth. This subject was stained with hæmatoxylin. The lack of detail in Fig. 7 is very marked, while there is abundant detail in Fig. 6. These two photographs are given to show again how bad effects may be transformed into good ones by the application of rational principles of " screening " as outlined by Mr. Hubbard. We are unable to state exactly under what condition these photographs were taken. The lack of detail in Fig. 7 may have been remedied either by working with no screen at all or by using a hæmatoxylin screen.

From a consideration of the foregoing discussion, and from a reading of Mr. Hubbard's presentation of the principles of the subject, it must be evident that no rules of thumb can be laid down for the use of ray filters, or so-called " color screens," in photomicrography. The worker who desires to obtain the best technical results intelligently must study not only his staining dyes with the spectroscope, but also his aniline-dye ray filters or " color screens." For this purpose

a small direct-vision spectroscope is all that is required, for the fine details of absorption bands may be neglected. Moreover, such a worker must have experience, and much more " first-hand " knowledge of photography than is required to work a pocket kodak or to develop a photographic nega-tive.

In conclusion, the writer desires to acknowledge his great indebtedness to Mr. J. G. Hubbard for giving him the benefit of his thorough knowledge of the optics of photography and microscopy, and for much practical instruction in photo-micrography.

The photographs which accompany this paper were made with the assistance of Mr. Louis S. Brown.

A NEW SPORE–PRODUCING BACILLUS.

Francis P. Denny.

The bacillus to be described was obtained by Dr. Langdon Frothingham, from sputum sent for tubercle bacilli examination. The patient from whom the sputum came had tubercular peritonitis and died several months later, probably from a general tubercular infection. The sputum when stained by the Ziehl-Neelsen-Gabbett method, though having no bacilli of tuberculosis, showed large bacilli containing bright red-stained spores. The bacillus was in nearly pure culture and was easily isolated on blood-serum streak cultures. I am indebted to Dr. Frothingham for cultures obtained in this way.

A few days ago I learned that Dr. Hopkins had isolated a similar bacillus from the mouth of a healthy individual. Dr. Hopkins very kindly gave me a culture of his bacillus, and I have found it to correspond in every way to this one. Dr. Hopkins says he has seen the bacillus several times in cover-glass preparations from the mouth. He is of the opinion that it is a not uncommon mouth form. Neither he nor I, however, have been able to identify it with any bacillus hitherto described.

Morphology. — It is a large bacillus varying greatly in size and shape under different conditions of growth. In bouillon the bacillus measures in fresh unstained preparations 3 to 5 μ in length, and about 1.2 μ in width. Grown at the room temperature, and on most of the other media, it is considerably smaller. It grows in chains, but is found singly or in pairs in fresh cultures. It stains readily in aniline colors. It is not decolorized by Gram's method. It has numerous flagellæ, as many as fifteen on one bacillus having been counted. They are readily stained by the van Ermengem method.

In twenty-four to forty-eight hours in the incubator (somewhat later at the room temperature) *spore formation* occurs. The spores are round or slightly oval shaped, and centrally situated in the bacilli. They stain readily by the Ziehl-

Neelsen method for tubercle bacilli, although it is best to use a more dilute acid, because otherwise some of the spores are decolorized.   After three or four days the spores are found outside the bacilli.   There they increase considerably in size, and appear in stained preparations as large, round, intensely stained bodies measuring often 3 or 4 μ in diameter.

Soon after the appearance of the spores in the bacilli there are found *oval spore forms* which will not stain well by any of the ordinary methods.   By the Ziehl-Neelsen method the oval forms are stained a faint red, best marked at the periphery so that the outline can be distinctly seen.   These oval forms are most common on media which is comparatively dry, like potato or agar, while in bouillon there are very few.

Biological character. — It is actively motile except when growing in long chains.   Chains of six to ten elements will sometimes progress in a given direction with a slow, snake-like motion.   That the very long chains also have flagellæ in active motion is demonstrated by the movements of small foreign particles which happen to come near them.   It is a gelatine liquefier, ærobic, and non-chromogenic.   It grows well on all the ordinary media, and most vigorously at the body temperature.

In *gelatine plates* colonies are developed in forty-eight hours.   They are round, and have a pale yellow color. Liquefaction advances slowly.

In *gelatine cultures* liquefaction begins in forty-eight hours as a depression on the surface, and extends during the next few days as a slender funnel-shaped depression to the bottom of the tube.

On *agar-agar* the growth is very rapid and vigorous.   After twenty-four hours in the thermostat there is a growth along the lines of inoculation 5 to 8 mm. in width.   The edges have a delicate wavy outline.   After a few days the surface of the growth may become wrinkled.

In *bouillon* at 37° there appears a slight cloudiness.   After twenty-four hours there is on the surface a thin glistening white pellicle, while the bouillon beneath becomes clear.   On moving the tube even slightly the pellicle is detached from the sides of the tube, and sinks to the bottom.

In *glucose bouillon* in the fermentation tube there was no gas production, and there was no growth at all in the closed segment.

Blue litmus glucose bouillon showed acid production.

On *blood serum* there is considerable growth in twenty-four hours. The serum is liquefied so that the surface may become deeply furrowed along the lines of inoculation.

On *potato* there is an abundant growth. It is raised, and has a dirty pale straw color.

Milk is coagulated at the end of twenty-four hours. The coagulum separates from the whey and is slowly digested, so that at the end of two weeks only very little of the curds remain at the bottom of the tube.

In *Dunham's peptone solution* there was production of indol, as shown by the test with sodium nitrite and sulphuric acid.

Vitality. — Cultures have retained their vitality for a period. of seven months. The bacilli and spores are killed by an exposure of fifteen minutes to the steam in the Arnold sterilizer.

Pathogenesis. — In rabbits no effects were observed from subcutaneous, intraperitoneal or intravenous inoculations.

In guinea pigs (weight about 500 gm.) 5 c.c. of a two days' bouillon culture can be injected subcutaneously without any other disturbance than the occurrence of a slight induration at the point of inoculation. The animals appear perfectly well, and usually gain in weight. One to 3 c.c. given intraperitoneally also produce no symptoms. When, however, 4 or 5 c.c. are injected intraperitoneally death usually occurs within twenty-four hours. Five guinea pigs killed in this way showed at autopsy injection of the coils of intestines, and a small amount of turbid fluid in the peritoneal cavity. No gross changes could be observed in any of the other organs. In all five the bacillus was obtained in pure culture from the abdominal cavity. In three, cultures from the liver, kidney, pleura, and heart's blood showed a few colonies of the bacilli. A few scattered bacilli were occasionally found in sections from the liver and kidneys. The

pathological changes suggest that the animals died from peritonitis, due to the irritation of the large amounts of bouillon containing much coarse material in suspension, rather than as a result of infection. From the fact that the guinea pigs were not affected by extremely large doses except when given intraperitoneally we are justified in concluding that the bacillus is *non-pathogenic.*

Serum clump reaction. — A well-marked clump reaction was obtained with the serum of guinea pigs and rabbits which had been inoculated with bouillon cultures of the bacillus. The method employed was as follows:

Bouillon cultures of less than twenty-four hours were used in making the test. As the bacilli grow in large masses on the surface it was necessary to shake the culture very vigorously, and then allow it to stand for a short time. In this way the clumps of bacilli settle to the bottom, while the single bacilli and short motile chains are diffused through the bouillon. Before inoculating the animals their blood was tested, but in no case was there any clumping, with a dilution of 1 : 4 and with a time limit of one hour. The animals were inoculated with varying amounts of a two-days' bouillon culture, and their blood tested from time to time.

With guinea-pig's serum a clump reaction appears in two to four days after a single inoculation of 5 c.c. After 10 c.c. have been injected the clumping is marked even with a dilution of 1 : 500. In rabbits clumping was observed after 11 c.c. had been given. The reaction was present with a dilution of 1 : 300. The blood of the guinea pigs which had died within twenty-four hours after intraperitoneal injections of large amounts of bouillon cultures did not give the clump reaction. The blood of the guinea pigs and rabbits inoculated six weeks ago retain their clumping power undiminished up to the present time.

The occurrence of the clump reaction with the blood of animals inoculated with this bacillus is chiefly of interest from the fact that the bacillus is not pathogenic. Strictly speaking, the reaction is neither the result of infection nor of immunity.

The bacillus resembles in many respects the *bacillus sub-tilis*. It is, however, a broader bacillus than the subtilis. It has a larger number of flagellæ. The growth on agar is more rapid and abundant. The spores are less resistant to heat. The serum of animals inoculated with this bacillus does not give a clumping reaction with the bacillus subtilis.

In concluding, I want to thank Dr. Ernst for the very beautiful slides and for a great deal of help in the work.

DESCRIPTION OF FIGURES IN PLATE.

FIG. 1. — Bacilli with spores in sputum.

FIG. 2. — Bacilli with spores, two days' growth on agar.

FIG. 3. — Clump reaction in bouillon culture with guinea-pig's serum, 1 : 20 dilution.

FIG. 4. — Same, showing clumping along a chain of bacilli.

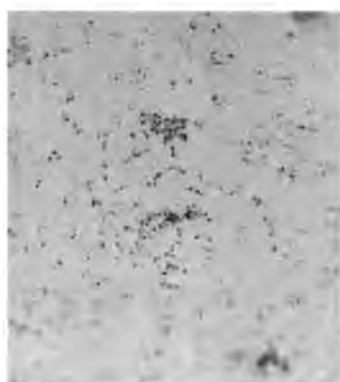FIG. 5. — Chain of bacilli, showing flagellæ. (van Ermengem stain.)
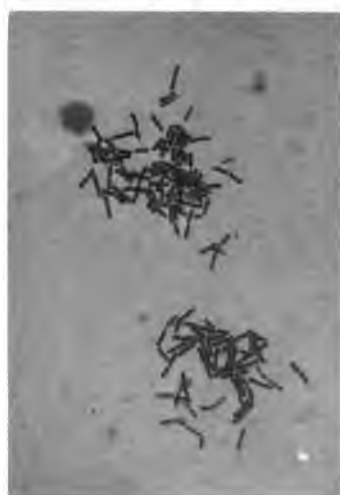
Fig 1. (X 300.)

Fig 4. (X 300.)

Fig 2. (X 300.)

Fig 3. (X 300.)

Fig 5. (X 300.)

THE RELATION OF THE DEPRESSOR NERVE TO THE VASOMOTOR CENTRE.[1]

BY W. T. PORTER AND H. G. BEYER.

(*From the Laboratory of Physiology in the Harvard Medical School.*)

It is conceivable that an afferent nerve, such as the depressor, should make connection, not with all the cells of the centre in which it ends, but with certain cells only. Thus it has been thought that the fall of blood pressure which is seen when the central end of the depressor nerve is stimulated is owing chiefly and particularly to the dilatation of the abdominal vessels innervated by the splanchnic nerve. Stated more precisely, this would mean that the depressor nerve was connected with the vasoconstrictor fibres in the splanchnic nerve in a way differing in degree, if not in kind, from its connection with other vasomotor fibres. In other words, the terminals of the depressor nerve could not be connected in the same way with all the cells of the vasomotor centre.

Obviously the method of solving the problem thus raised must consist in the comparison of the effect of stimulation of the depressor nerves before and after the separation of the splanchnic nerves from the vasomotor centre. Should the effect on the blood pressure be as great after the splanchnic nerves are severed as when these nerves are intact it is plain that the depressor nerve does not work specially through the splanchnic nerves but through the vasomotor centre as a whole; for there is no reason to suspect a specific relation to other vasomotor nerves.

In practice the method just outlined presents the difficulty that the separation of the splanchnic nerves from the vasomotor centre causes so great a fall in blood pressure that no quantitative measurements of vasomotor effects are possible thereafter. This difficulty, however, may readily be overcome by stimulating the peripheral ends of the severed

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[1] The full paper will be published in the American Journal of Physiology.

splanchnic nerves until the blood pressure rises to normal again. While this normal level is thus maintained the depressor nerves are excited electrically. The fall in pressure then observed is due, of course, to the dilatation of vessels supplied through nerves other than the splanchnic.

The results of numerous experiments by this method show that the fall in blood pressure produced by depressor stimulation is not essentially less after exclusion of the splanchnic area. The fall observed in the intact animal, therefore, is not due specially to the dilatation of the abdominal vessels. Consequently there is no reason for supposing that the depressor nerves are specially connected with the bulbar cells through which the splanchnic fibres receive their constrictor impulses.

THE RELATION OF DEXTROSE TO TOXIN PRODUCTION IN
BOUILLON CULTURES OF THE DIPHTHERIA BACILLUS.

THEOBALD SMITH, M.D.

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Preliminary Note.

Up to the present it has been generally held that the vary-
ing and often disappointing amounts of diphtheria toxin
which are obtained from cultures of the diphtheria bacillus
in bouillon made from beef in the usual way are referable to
the presence of variable amounts of muscle sugar which is
promptly converted into acids by the diphtheria bacillus.
This view was first published by Spronck and Van Turenhout
(1895), who endeavored to remove this sugar by allowing the
beef to partially decay before use. The writer arrived at
similar results independently by comparing the toxin pro-
duction with the amount of fermentescible substance in
different lots of beef as revealed by the fermentation tube.
Since that time various articles on the preparation of bouil-
lon for toxin production have appeared without essentially
modifying the views presented. The great practical impor-
tance of this subject as it bears directly on the preparation of a
concentrated antitoxin has been the reason for a more minute
and detailed study of this restricted field. The method of
Spronck was soon found unreliable, and in 1897 I published
a method for removing all fermentescible substances from
beef which yields invariable results. Since that time the
fermentation of beef has come quite generally into use.

In the course of experiments having in view the concen-
tration of toxin in bouillon cultures I soon found that dex-
trose could be added to bouillon from which the muscle
dextrose had been removed without interfering with toxin
production. In fact, the addition of about 0.1 per cent.
actually favored the accumulation of toxin so that now the
largest amounts are obtained by first removing from the beef
the muscle sugar by fermentation and then adding to the

finished bouillon a definite but limited amount of dextrose. The details of the method of preparing such bouillon will appear in a forthcoming article in the "Journal of Experimental Medicine."

The explanation of the different behavior of diphtheria bacilli in ordinary bouillon and in the bouillon prepared as above outlined can at present be only conjectured. If we follow the course of the reaction in the culture fluid certain differences are made manifest. In the ordinary bouillon the amount of acid is promptly increased in proportion to the muscle sugar present, and then the reaction either remains indefinitely stationary or slowly returns to an alkaline level. In the specially prepared bouillon the acidity is likewise promptly increased, but it is at once followed by a rapid return to an alkaline reaction. The diphtheria bacillus is able to neutralize a much larger amount of acid derived from dextrose than from muscle sugar. In view of these different reaction curves the question presents itself whether the acids formed by the diphtheria bacillus out of the muscle sugar are different from those formed out of the added dextrose, and whether the latter are assimilable by the bacillus and the former not. Or, in other words, does the diphtheria bacillus form out of these sugars acids as different, for instance, as sarcolactic and the ordinary lactic acid resulting from bacterial fermentation? This hypothesis is made probable by the outcome of experiments which were made to determine the effect of different concentrations of acids upon the finished toxin. When dextrose in sufficient amount is added to bouillon cultures which have reached the limit of growth and are highly toxic, growth is resumed by reason of the acid production. This latter process goes on until the toxin is completely destroyed and subsequently the bacillus as well. The acid production comes to a stop when the reaction corresponds to 4.5 to 5 per cent. of a normal solution. To determine at what concentration the injurious effect on the toxin begins chlorhydric and lactic acid were added to finished filtered toxin in different amounts and the mixture placed in the incubator. The slow destruction began

when the reaction corresponded to 2.5 to 3 per cent. of a normal solution of acid.[1]   Above 3 per cent. the destruction was more rapid.

These tests indicate that the acidity produced in presence of muscle sugar is not to be looked upon as the chief destructive agent, as it rarely rises above 3 per cent.   Hence the hypothesis already stated — that the acid formed from the muscle sugar by the diphtheria bacillus is not assimilable, while the acid derived from the ordinary dextrose is assimilable.   The problem may be and probably is much more complex than this and must be left for physiological chemistry to clear up.   The glycogen which I at first suspected was not involved, because tests with this substance showed that the diphtheria bacillus does not attack it.   To explain the great increase in the toxin-producing capacity of the specially prepared bouillon it was assumed that it might be due to the preliminary fermentation, but such fermented bouillon yielded only a trace of toxin when peptone was withheld.   Other bacterial toxins were not detected in fermented bouillon, for guinea pigs were not affected by large intra-abdominal doses of the sterile fluid.

The muscle sugar is generally regarded as identical with dextrose, and it is acted upon by certain groups of bacteria just as dextrose, is.   Nevertheless there may be a difference, not appreciable when chemical methods are applied, but requiring biological tests such as are afforded by the selective action of different bacteria on carbohydrates.

The diphtheria bacillus, although possessing in common with facultative-anaërobic bacilli the power to break up dextrose, is essentially aërobic.   The maximum toxin-producing power is exercised only when the bacillus grows in cohesive membranes on the surface of the culture fluid. Park and Williams were, I believe, the first to cultivate the diphtheria bacillus exclusively in bouillon to develop the membrane form of growth.   Any diphtheria bacillus growing diffusely in fluids may, in 5 or 6 passages through bouillon, be made to assume the strictly membranous type of growth,

[1] Approximately o.1 per cent. HCl.

and when this has been established the maximum toxin production may be expected. I have thus far increased the toxin production of two diphtheria bacilli by a combination of the methods outlined so that the minimum fatal doses of .04 c.c. and .05 c.c. for a guinea pig of 250–300 grams, as obtained by the method of Spronck, have been reduced to .007 c.c. and .015 c.c. respectively. With this method it will not be difficult, I think, to readily find diphtheria bacilli that will yield toxin with a minimum fatal dose of .01 c.c. and less.

The marked difference in the toxicity of bouillon cultures prepared in different ways should induce bacteriologists to be exceedingly cautious in claiming an actual increase in virulence for bacteria treated in different ways, when such increase may depend entirely on the environment and may be modified at will by changing the medium.

In all comparative tests of toxicity only guinea pigs raised under the same conditions should be used. Animals from certain sources may exhibit twice the susceptibility of those from others.

PHYSIOLOGICAL ACTION OF EXTRACTS OF THE SYMPATHETIC GANGLIA.[1]

By Allen Cleghorn.

(From the Laboratory of Physiology in the Harvard Medical School.)

In February last I reported to this society the results of some preliminary experiments made with extracts of the various sympathetic ganglia of the dog and cat.[2] These experiments showed a large fall in the systemic blood pressure when the extract was intravenously injected, but they did not show whether the fall in blood pressure was due to a peripheral or central action. The following experiments show that the dilatation is peripheral:

1. During perfusion of the cat's bulb, isolated from the systemic circulation, with defibrinated blood, the addition of sympathetic extract to the perfusion fluid causes no change in the systemic blood pressure.

2. On exclusion of the bulbar vasomotor centre by ligation of all head vessels, division of the cord immediately below the medulla, and restoration of the systemic blood pressure to its normal level by electrical stimulation of the peripheral end of the cord, the injection of the extract into the femoral vein causes a fall in the systemic blood pressure.

3. Perfusion of the extract, mixed with blood, causes an increased flow through the vessels of the isolated hind limb, kidney, and submaxillary gland of the dog and cat.

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[1] The full paper will be published in the American Journal of Physiology, 1899, ii, p. 471.

[2] Cleghorn. This Journal, 1899, iii, p. 207.

THE ORIGIN OF FIBRINOGEN.[1]

ALBERT MATHEWS.

(From the Laboratory of Physiology in the Harvard Medical School.)

The origin of the three chief proteids of the blood plasma, fibrinogen, paraglobulin, and serum albumin, is at present obscure. The observations of Miescher, Panum, Burckhardt, and others, showing that these proteids do not diminish during fasting, indicate that they are formed in the body itself. From the work of Mörner, Kossel, and Schmidt it is probable that paraglobulin is derived from the chromatin of the leucocytes upon decomposition of the latter and after the nuclein bases and phosphoric acid have been split off. Little is known of the origin of fibrinogen. Schmidt's conclusion that it is derived from paraglobulin is entirely unfounded. Dastre has recently urged that the lungs, skin, and intestine form fibrinogen, while the other tissues and organs consume it. This conclusion rests, however, on determinations of the fibrinogen content of the blood before and after passing these organs, a method which by itself does not give a reliable result. The blood from the pulmonary vein was sometimes poorer sometimes richer in fibrinogen than the blood in the pulmonary artery. His observations do not permit, hence, any positive conclusion as to the origin of fibrinogen.

In the present investigation the fibrinogen was removed from the blood of cats and dogs by repeated bleedings, defibrination of the blood thus drawn, and its reinjection. One-third of the total blood was withdrawn each time; this was repeated six or seven times. After defibrination various organs were extirpated and the effect of the absence of the organ on the reformation of fibrinogen was noted. Examinations were also made of the fibrin content of the blood before and after passing various organs. The following results were obtained:

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[1] Abstract to be published in full in the American Journal of Physiology.

1. No serious symptoms follow defibrination in cats. The temperature of the body falls 1°–2° C., but quickly recovers.

2. The fibrinogen is reformed readily in the normal cat. In 24–36 hours it reaches its normal amount or may surpass the normal amount.

3. Fibrinogen formation is increased, rather than decreased, by the absence of the spleen, pancreas, kidneys, reproductive organs, brain, or most of the muscular system. These organs are not, hence, necessary to the reformation of fibrinogen.

4. Extirpation of the small intestine greatly decreases, or altogether inhibits, the power of fibrinogen formation.

5. The loss of the clotting power of the blood after cutting the intestinal area out of the circulation observed by Stolinkow, Pawlow, and Bohr is not due to any absence of fibrinogen. It is due to the absence of the intestine and is not dependent on the presence or absence of the spleen, liver, or pancreas.

6. The blood of the inferior vena cava before its junction with the hepatic vein contains always 0.01–0.02 % less of fibrinogen than the carotid blood. This is true also for the jugular blood. The observations of Dastre show that in passing through the lungs the per cent. of fibrinogen in the blood as a rule slightly diminishes.

7. The blood of the mesenteric vein always contains .01–.02 % more of fibrinogen than the arterial blood.

8. Fibrinogen is not derived directly from the proteids of the food. Cats fasting 7–10 days showed no diminution in the power of reforming fibrinogen.

9. There is no direct relation between the number of leucocytes in the blood and the per cent. of fibrinogen. A large per cent. of fibrinogen may, but does not always, coincide with an increase in the number of leucocytes.

10. If leucocytosis persists, however, for twenty-four hours or longer the percentage of fibrinogen is enormously increased, in some cases being more than six times the normal amount. Suppuration, however produced, always causes an increase in the percentage of fibrinogen present in the blood.

There appears to be, hence, a relationship between leucocytic decomposition and the amount of fibrinogen present.

From the foregoing observations the conclusion may be drawn that fibrinogen is derived from the decomposing leucocytes, chiefly those of the intestinal area. It possibly corresponds to that constituent of the body of the leucocyte which falls into a fibrillar form during karyokinesis. Karyokinesis and the clotting of blood are possibly identical processes.

SPECIAL NOTICE.

The Journal will be · published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will · be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

All communications should be addressed to the Editor.

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JOURNAL

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CONTENTS.

A PRELIMINARY STUDY OF STREPTOCOCCI ISOLATED FROM
THROAT CULTURES FROM PATIENTS ILL WITH SCAR-
LET FEVER.

CALVIN G. PAGE.

(From the Bacteriological Laboratory of the Harvard Medical School.)

Through the courtesy of Dr. John H. McCullom I made
cultures from throats of twenty-four scarlet-fever patients a
few days after their entrance into the South Department of the
Boston City Hospital. I examined the cultures at the Harvard
Medical School.

In all of the twenty-four cases except one I found a strep-
tococcus in the primary cultures, but I failed to isolate a
streptococcus in five cases.

The method of isolation first used was spreading dilutions
of the original culture on solid blood-serum plates or tubes.
Later I used plates of melted agar-agar, prepared with bouil-
lon containing a small proportion of blood serum.

Of cultures from thirteen cases inoculated in milk, those
from six coagulated the milk, and those from six did not,
and cultures from one case did both, alternately. ¶ have

obtained a good growth of streptococcus from a coagulated milk culture two months old.

In bouillon cultures the length of the chains varied greatly. Out of twenty cases I found fourteen where the chains were relatively long, while in six cases the chains remained short, even under conditions most favorable for growth.

The streptococcus cultures isolated from twelve cases were grown in sugar bouillon. For various reasons the cultures from the other cases had to be abandoned. The importance of the knowledge gained by growing other organisms in fermentation tubes filled with bouillon containing different sugars has been pointed out many times (1) by Prof. Theobald Smith, and in applying the method to streptococcus cultures I hoped to find some help in the problem of differentiating species of streptococci.

The bouillon was made from meat and freed from dextrose or muscle sugar by fermenting the meat infusion with the colon bacillus before cooking. In the later experiments I used bouillon prepared substantially according to the method described by Martin (2) for producing diphtheria toxine, at the Pasteur Institute.

In each lot of bouillon, I made the final acidity about 1 %. To portions of bouillon I added 1 % dextrose (anhydrous grape sugar Merck), 1 % lactose (milk sugar), and 1 % sucrose (ordinary granulated sugar). Each portion was put in fermentation tubes and sterilized, as was also some of the sugar-free bouillon. Instead of fermentation tubes I used later double tubes as suggested by Dunham (3). When no attempt is made to study the kind of gas produced, or, as in this particular work, when no gas whatever was formed, they are just as good.

The acidity of a culture is determined by neutralizing a measured quantity of the bouillon with a standardized alkali solution, using phenolphtalein to indicate the neutral point. The amount of alkali used is the measure of the acidity of the culture. The following example shows how, by neutralizing 5 cubic cm. of bouillon with one-twentieth normal sodic hydrate solution, we get at once the percentage of acidity (4).

For example:

Bouillon culture of streptococcus (case 4) . . . . 5. c.c.
      Water . . . . 45. c.c.

Boil 3 min. in evaporating dish and add sol. phenolphtalein . . . . 1. c.c.

Titrate while hot with $\frac{n}{20}$ NaOH from burette.

Stop when mixture remains pink.
Reading of burette before titrating . . . . 3.00 c.c.
Reading of burette after titrating . . . . 6.80 c.c.

Amount $\frac{n}{20}$ NaOH required to neutralize 5 c.c. culture = . .

Amount $\frac{n}{1}$ NaOH required to neutralize 100 c.c. same = . .

Percentage $\frac{n}{1}$ NaOH required to neutralize same = ...   3.80

Percentage of acidity in terms of $\frac{n}{1}$ NaOH with regard to the

  phenolphtalein neutral point = ...
% acidity sterile control bouillon 1.00

Increase % of acidity 2.80

This table shows the results, the figures representing in every case an increase in percentage of acidity. The increase in the sugar-free bouillon is very slight, showing that the acidity must be due to the presence of sugar. The figures on the same horizontal line represent results where the conditions of the experiment were exactly similar. It is the relative value of these figures rather than their absolute value that interests us. Is the acid produced in lactose more or less than the amount produced in the other two? In many cases the amount is nearly the same or intermediate. In case 18, however, the figures are 5.8, .8, and 6.2, while in case 20$_a$ we find 2.7, 4.5, and 3.4. If we could get constantly such strikingly different results between two cultures of streptococcus we might have some ground for regarding them as belonging to different species. The figures of course do not warrant any such assertion in these cases. The average increase is 3.5% for dextrose, 3.4 for lactose, and 3.9 for sucrose, which is not very different from the theoretical result calculated as lactic acid.

The coagulation of milk is due to the production of lactic acid from milk sugar. The uncertainty of the result in streptococcus cultures is due partly to the variation in the acidity of the milk when inoculated and partly to other conditions of the milk not well understood. Prof. T. Smith has pointed out (4) that a milk culture will often ˉcoagulate on heating.

By adding neutral solution of litmus to milk or bouillon one can watch the progress of the production of acid. But as the litmus interferes with the color end reaction of the phenolphtalein test, I prefer instead of litmus to add to culture media a very small quantity of fluorescein (5). This gives a yellow solution with a green fluorescence seen by reflected light. When the solution becomes acid the fluorescence disappears. The neutral point is nearly that of litmus. By using media thus colored one can tell at a glance if acid has been produced, and if for any reason it is desired to determine the amount of acid, the presence of the fluorescein does not interfere with the end reaction of the phenolphtalein test.

Streptococci did not produce any gas in the fermentation tubes of sugar bouillon. In nearly all the cultures I made,

Case Number	Increase in % of Acidity				
	Dextrose	Lactose	Glucose	Bouillon	Milk
4	2.80	5.	4.50	.30 / .30	3.20 / 3.80 / 5.80
		5.50	3.	.50	May 7.80
8		2.40 / 1.80 / 2.70	2.40 / 2.40		
	1.40				
9	2.56 / 2.80	2.88 / 3.44	4.72		
10	6.32 / 6.92	5.12 / 6.84 / 5.44			
13	.28	1.03 / 2.58	1.21		May 0.76 / 2.28
14	1.20 / 4.82 / 3.87	2.88 / 3.27	3.87 / 6.34		1.52 / .60 / .48
15	3.84 / 2.06	4.23 / 3.10	4.18		May 4.18 / .91 / .33
16	.64	.44	1.96		
18	5.78	.84 / 1.24 / 1.64	6.18 / 5.11 / 4.91	0.	
19	2.04	1.98	3.24	.10	
20	a. 2.71 / b. 5.65 / a. 5.71 / b. 5.21	4.51 / 4.74 / 4.56 / 5.24	3.56 / 3.94 / 5.24 / 5.24	.20 / .40	
21	3.88	5.58	4.58	.50	
Average	3.47	3.38	3.92	.35	

however, there was more or less growth in the closed arm of the tube where there is no air.   But growth was always less than in the open arm, for the tests show that the amount of acid produced in the closed arm was smaller in every case, the average difference being one-half of one per cent.

In a general review of the subject of streptococcus, Lemoine (6), writing in 1897, traces the changes in scientific opinion regarding the identity of different varieties of streptococcus.   He shows that every peculiarity of cultural or microscopic appearance that has been relied upon in the past to indicate a difference in species can be reproduced by appropriate means in all the different varieties.   And yet the fact that varieties of streptococcus are not identical is shown by recent experiments in immunity, reported by Denys (7).   Animals made immune to one variety of virulent streptococci reacted strongly when inoculated with a small dose of another variety.

One of the manufacturers of anti-streptococcus serum. emphasizes this point, declaring that his horses have been made. immune to a number of varieties of streptococci, thus giving the serum a wider range of usefulness.

The difficulty of keeping a culture of streptococcus alive has been explained by Marmorek in a recent note (8).   In ordinary bouillon growth ceases after about two days, though the culture may remain alive for two weeks.   Marmorek found that by adding a little sterile meat extract to a culture every day he could keep up growth for some time.   He points out further that if the organisms are filtered out of a bouillon culture of a streptococcus and the fluid reinoculated with the same streptococcus there will be no growth.   Other bacteria, however, if planted in the fluid, will grow readily.   He suggests that this makes a useful method of freeing a mixed culture from streptococcus.   He finds that all varieties of streptococcus have this property, and it is for him an argument for the unity of the species.   He says that the bacillus of fowl cholera and the pneumococcus have this property of refusing to grow in their own toxine, as it were, while the

bacillus of diphtheria, the bacillus of tetanus, and the Asiatic cholera vibrio will grow indefinitely in their own toxine.

In order to get a better medium for growing streptococcus I added about five per cent. of blood serum to bouillon. The method was not satisfactory, however, until I learned to prepare fluid blood serum that could be sterilized by heat without coagulating. This was done by adding about 2% " Nutrose " to diluted serum, following carefully the directions given by Wasserman in his article on cultivating the gono- coccus (9). By adding a little of this fluid serum the bouil- lon becomes only slightly opalescent. If there is sugar in the bouillon a growth of streptococcus will begin to precipi- tate the serum as soon as the culture becomes acid. I have found that streptococci grow well in this serum bouillon.

This precipitation of alkali-albumen in the presence of an acid forms the basis of a recently described method for test- ing acid production by bacteria. Hanna (10) fermented sev- eral kinds of sugar with a number of species of bacteria, but not streptococci.

Conclusion. — 1. The streptococcus fermentation of dex- trose, lactose, and sucrose bouillon produces in each a con- siderable quantity of acid.

2. The quantitative determination of the amount of acid produced from each sugar is probably not an important aid to separating varieties of streptococci.

3. The qualitative demonstration of the production of acid by the presence of litmus or fluorescein in the culture media containing sugars may prove useful in showing a peculiar fermentation reaction in some varieties of strepto- coccus.

4. Streptococci will grow and make acid from sugar when no air is present, but oxygen favors both growth and fermen- tation.

5. The addition of fluid blood serum to sugar-free bouil- lon makes a medium favorable to the growth of strepto- coccus.

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PRELIMINARY NOTE ON THE EFFECTS OF CHANGES IN EXTERNAL TEMPERATURE ON THE CIRCULATION OF BLOOD IN THE SKIN.

THEODORE HOUGH AND BERTHA L. BALLANTYNE.

(*From the Biological Laboratory of the Massachusetts Institute of Technology.*)

The pressure of the blood in the capillaries, unlike that in the arteries and veins, cannot be measured directly; and thus far we have only one way of indirectly determining it; this is the well-known method introduced by N. v. Kries, in 1875, and consists in measuring the amount of pressure which must be applied to a known area of skin in order to cause the disappearance of the red color, or else to stop the circulation actually observed in a transparent tissue under the microscope (Roy and Brown). In our experiments we have used the original method of v. Kries, so modified as to permit very rapid determination, a greater possible number of observations, and graphic record of the results. The glass square of known area (9 sq. mm.) is fastened by means of Canada balsam to a second rectangular piece of glass which projects about an inch from one arm of a counterpoised lever, to which it is firmly attached; hence when the glass square rests upon the skin it exerts no pressure. Pressure is applied by the extension of the calibrated brass spiral spring attached to the long-lever arm at any desired distance from the fulcrum; the spring is stretched by means of a light but inextensible thread attached to it below, and passing over a pulley, directly underneath, to the hand of the observer. The thread carries a light writing point, which records on the slowly travelling surface of a kymograph. It is thus unnecessary to read the amount of extension of the spring at the time of taking the observation; the entire attention of the observer is given to the color changes, obviously a very great gain. Each reading, moreover, takes but a few (3 to 10) seconds; hence the readings can be repeated quite frequently, thus aiding in the elimination of error.

PLATE I.

FIG. 1.

All observations were made on the skin of the dorsal surface of the finger just behind the nail, the arm resting comfortably on a suitable support and as unconstrained as possible. The end-point chosen was the entire disappearance of color; although not giving as correct absolute values as the first distinct change of color it is more convenient and, where only comparative measurements are required, equally exact.

Notes were made in all experiments of the size of the dorsal metacarpal veins, as affording some indication of the amount of blood flowing through the skin of the fingers. Distension of these veins may be due to two causes: either the vascular bed offers comparatively little resistance to the flow of blood from the large arteries to these veins, that is to say, there is arterial dilation in the hand; or there is some resistance to the onward flow of blood in the large veins. It is conceivable, for instance, that an increase of 15 cm. (water) pressure in the vena cava superior should cause enlargement of the dorsal metacarpal veins, apart from any considerable increase in the blood-flow through them; we do not think, however, that there can be any doubt that, as a usual thing, the size of these veins is dependent upon the amount of arterial dilation rather than upon venous obstruction; their collapse would certainly indicate a small blood-flow, and this is the only condition of the veins which affects our conclusions to any extent.

Our observations were made upon three individuals. It seemed that in the time at our disposal more valuable results would be obtained from a large number of experiments with each of a few individuals than from a few experiments with each of a greater number. Observations will be made in the future upon larger numbers and with special reference to individual differences in the reaction to changes of temperature, for it is highly probable that such individual differences exist; the results given in this paper, however, were observed in each of the subjects of our experiments.

In all our work we have been impressed with the fact that capillary pressure does not vary directly with the apparent

amount of blood flowing through the skin. If the regulation of the circulation in an organ is practically a matter of arterial dilation or constriction, as is tacitly assumed in much of our present physiological teaching, we should expect to find high capillary pressure going along with the greatest flow of blood, and vice versa. In point of fact, some of the highest capillary pressures were observed on prolonged exposure to cold air, when the veins were almost invisible; and it was by no means an uncommon occurrence to find capillary pressure but slightly raised on exposure to warm air when the veins indicated a large cutaneous circulation. This only emphasizes the danger of using plethysmographic tracings as an indication of the amount of arterial dilation.

Effects of cold air. — The following experiment is typical of the general results. The subject of experiment had rather high capillary pressures, that at the room temperature (20°–21° C.) varying from 40 to 50 mm. of mercury.

Time.	Room Temperature.	Cap. Pressure.	Veins.	Color of Hand.
2.25	20.5	40.6	Distinct.	Normal.
2.33	7	40.6	Less evident.	Normal.
2.38	7	44.7	Less evident.	Paler.
2.41	3.5	54.2	No change.	
2.55	6	65	Almost invisible.	Very red.
3.05	4	56.9	Almost invisible.	Very red.
3.12	8	56.9	Almost invisible.	Becoming bluish.
3.20	13.5	51.5	....	More normal.
3.25	16	48.8	More evident.	
3.35	17	46	More evident.	
3.45	18	40.7	No change.	
4.00	19	40.7	No change.	
4.15	19.3	51	No change.	Normal.

This shows clearly a rise of capillary pressure going along with almost complete disappearance of the veins, and hence presumably with greatly diminished blood-flow; in fact, on prolonged exposure to cold, the hand, at first red, later generally became more or less cyanotic, indicating a certain amount of stasis of blood in the capillaries.

Effects of warm air. — Our experiments deal only with temperatures between 21° and 26° C.; in all these cases a rise of 1° or 2° above the ordinary room temperature (20°–21°) would cause the veins to stand out very distinctly without, as a usual thing, greatly raising capillary pressure; thus in the subject of the previous experiment it was unusual to find pressures higher than 55 mm. Hg.; sometimes 60 mm. was observed, but generally it was not more than 50 mm.; in other words, a marked increase in blood-flow and hence arterial dilation, with only slightly increased capillary pressure.

Immersion in very cold or very warm water produced the same general effects as prolonged exposure to cold or warm air; naturally the temperature of the skin was changed more rapidly and the effects were more striking. With very cold water (5°–9° C.) it was found that on removing and rapidly drying the hand, capillary pressure would be very high for some minutes, the veins almost invisible, while the hand would show the characteristic "glow" of the cold bath; gradually this glow would pass off, and it did so as the veins became more evident and capillary pressure fell. This obviously renders doubtful the prevalent idea that this "glow" indicates increased cutaneous circulation; in almost all cases it was preceded for a very short time by pallor, low capillary pressure, and collapsed veins; and this was usually the condition of the hand while in the water. The experiments with hot water have not led to such uniform results; the metacarpal veins always enlarged, and at times capillary pressure rose to 60 mm. Hg. or more; generally, however, it was but little over 50 mm. When the hand was first kept in hot (45° C.) water and then in cold (5° C.) for two minutes the

diminished blood-flow through the skin was never observed, as when exposed to cold water alone.

The results of our experiments would seem to show that at times there is a rise of capillary pressure going along with arterial constriction (effects of marked cold), and that at other times capillary pressure remains constant or shows only a slight rise when there is pronounced arterial dilation. In other words, capillary pressure is dependent upon some other factor or factors than the amount of arterial tone. I should like to suggest that all our results are explained by supposing that the muscular coat of the small veins may be the other factor in question; if this constricts and dilates with the constriction and dilation of the arterioles we could have fairly constant capillary pressure with great variations in the amount of blood flowing through an organ; the inconsiderable changes in capillary pressure which at times accompany the marked arterial dilation produced by exposure to heat would be because of concomitant venous dilation, which permits an easier egress of blood from the capillary region; the rise of capillary pressure which at times accompanies the arterial constriction produced by exposure to marked cold would be due to the excessive concomitant constriction of the venules, which hinders egress of blood from the capillary region. May it not be that while the muscular coat of the small arteries regulates the *amount* of blood flowing to an organ the capillary *pressure* is regulated by the simultaneous action of the muscles of both arterioles and veins?

BACTERIA AND DENTAL CARIES.   (PRELIMINARY REPORT.)

S. A. HOPKINS, M.D.   ·

(*From the Bacteriological Laboratory of the Harvard Medical School.*)

This work was undertaken to discover, if possible, the causes which lead to dental caries.   It seemed reasonable to hope that if the various processes of tooth decay could be accurately followed some suggestion for preventing or at least retarding the process might arise.

There have been many theories promulgated to account for the destruction of the teeth, and it is unnecessary to review them all.

Up to ten or fifteen years ago the theory generally received was that which ascribed to chemical action alone the destructive changes which take place in the human teeth.   About that time, Miller, of Berlin, who did excellent work in the study of the bacteria of the human mouth, found, as he believed, that the destruction of the human teeth was an acid process due to the action of lactic acid.   This lactic acid, he believed, was produced by bacteria which found a suitable media for their development in the food particles which remained in the mouth after eating and which became mixed with broken-down epithelial cells and saliva.   This was generally known as the chemico-bacterial theory and is the theory almost universally held at the present time.

The notable differences which were seen to occur in the action of the destructive agents upon teeth in different mouths and upon different teeth in the same mouth were supposed to be due to differences in the structure of teeth which made some teeth much more resistant to caries than others.

Three or four years ago Dr. Black, of Indiana, conducted series of experiments which must have been as laborious in character as they were surprising in results.   He subjected a very large number of extracted teeth to a very great variety of tests.   He measured their specific gravity, subjected them to various pressure tests, made microscopical examinations

of sections, and subjected them to analysis to find out the proportion of lime salts and other substances of which the teeth were composed.

At the end of his experiments he surprised the world with the astonishing statement that practically no physical differences were shown in the teeth examined that could throw any light on the question of the susceptibility of teeth to caries. He allowed the inference to be drawn that so-called poor teeth did not differ materially from those which were usually characterized as strong. He concluded that the destruction of teeth was due to environment alone and that no differences in strength could be considered an important factor in the carious process.

To the credit of the dental profession be it said, these conclusions have not been received without question, and the idea of susceptibility and immunity still has its supporters.

When the present work was undertaken it was with the hope of determining, first, whether caries was due simply to the presence of lactic or some other acid, and was a chemical process in which bacteria were merely producers of the chemical agent, or a more direct action of one or more forms of the bacteria found in the mouth. Second, whether the same agents acted on the enamel and dentine alike. Third, whether teeth from one mouth were more resistant to these influences than teeth from another.

It seemed to us that in these experiments we could not do better than follow the laws which Koch has laid down to govern investigations of diseases of supposed bacteriological origin.

For the fulfilment of the first law, viz., to establish the constant presence of the forms we are using, cover-glass preparations are constantly made from the mouths of patients, and records are kept of the age, sex, and physical condition of the patient and of the condition of the teeth. At the same time cultures are constantly being made with the object of obtaining as many pure cultures as possible for use in these experiments. About forty forms have been isolated in pure cultures by Dr. Coolidge, who has been associated with me

in this work and to whom I am greatly indebted, and while many of these cultures are repeatedly found in the mouths examined, we have found adequate descriptions of but a comparatively small number in the text-books on the subject.

Many of the forms seen in cover-glass preparations, especially the spirilla and leptethrix forms, we have as yet failed to cultivate, and it is possible that some of the most important destructive changes may be induced by these microorganisms which have thus far baffled all attempts to cultivate them.

After establishing the frequent or constant presence of a microörganism in the mouth, and then having secured a pure culture of the form, the third step in the work is to produce the disease. For the fulfilment of this part of the work the method is somewhat as follows: I have placed myself in communication with a number of extracting establishments in this and neighboring cities, and have freshly extracted teeth sent to me nearly every day. Notes are made of the age of the patient and of the general condition of the teeth in the mouth from which they were extracted. These teeth are cleaned and filled by an assistant, who then drills through the enamel in one place and exposes the dentine. In another spot the enamel is roughened with a file so that we have three points of observation on a single tooth, viz., the uninjured enamel, the bruised or cut enamel, and the dentine. After thorough sterilization, three teeth treated as I have indicated are put into the same tube — one so-called strong tooth, one frail tooth, and one of average texture, as indicated by the condition of the mouth from which they came, so that besides the three points of observation on each tooth we have three different classes of teeth to observe.

Of course we realize perfectly that an extracted tooth may not fulfil the conditions of a living tooth in the mouth, and we may find in this another cause of failure, but thus far we have been surprised to see how nearly the changes which occur in these teeth coincide with the action which takes place in the mouth as we see it clinically.

The tubes containing teeth treated as I have indicated and containing also 1 per cent. glucose bouillon are then inoculated. We have fixed upon 1 per cent. glucose bouillon as the most convenient and satisfactory variety of media, although we do not confine ourselves to that alone, frequently employing potato, liquid serum, and various saliva mixtures.

Of the many forms isolated from the mouth I should say at least one-fifth of the number are producers of lactic acid, but the strongest acid we have yet produced is one-half of 1 per cent. I am indebted to Dr. Charles Harrington for the chemical analysis and for other information on this subject.

Besides these lactic-acid producers there are other forms which cause a strong alkaline reaction, and cultures of these are also used to inoculate the tubes containing teeth.

After inoculation the tubes are placed in the incubator and from time to time fresh culture medium is added and the reaction of the tubes tested. Cultures are also made from time to time in order to determine that no contaminations have crept in and that the original microörganism is still active. In many cases we have found that the microörganism was destroyed by the fermentation which it produced. Frequent renewal of the culture medium will usually prevent this.

It is probable that lactic acid of the strength of one-half of 1 per cent. is never present in the mouth, since it is found that in the majority of cases where dental caries is going on rapidly the saliva has a marked alkaline reaction, and that there is a great deal of it. It is possible that the irritation caused by the caries may increase the action of the salivary glands. The alkalinity of the saliva is usually more marked in these cases than in those mouths in which the carious process is absent. For control tubes we use sterilized saliva, commercial lactic acid reduced to a strength of one-half of 1 per cent., and the bouillon rendered acid or alkaline by the mouth forms and afterwards sterilized.

From these experiments we have not been able to deduce any definite laws or point to very positive results. From the fact that teeth subjected to one-half per cent. lactic acid

in control tubes for four months show no carious action it may be inferred that something more than the mere presence of the acid is necessary to bring about the change.   The fact that artificial caries takes place in the dentine of teeth in tubes having a constant alkaline reaction points to the probability that an acid is not essential to the carious process in dentine.   The fact that some teeth in these tubes were not acted upon while others treated in the same way and contained in the same tube showed positive results points to the probability that some teeth are much more resistant than others.

SOME DEVICES FOR THE CULTIVATION OF ANAËROBIC BAC-
TERIA IN FLUID MEDIA WITHOUT THE USE OF INERT
GASES.

THEOBALD SMITH, M.D.

(*From the Laboratory of Comparative Pathology, Harvard Medical School.*)

The multiplication of anaërobic bacteria in bouillon from which the air is not wholly excluded was first pointed out by Kitt[1] in his study of the bacillus of Rauschbrand. It had been noted by various observers before Kitt that anaërobic bacteria will multiply and produce spores on the inclined surface of ordinary cotton-plugged agar tubes when they are mingled with aërobes; in other words, when the culture is a mixed or impure one. Within the past few years the associated growth of anaërobes and aërobes in culture media freely exposed to the air has been the subject of a number of publications. It is not the object of this paper to enter into a discussion of the literature or the various hypotheses which have been brought forward to explain anaërobiosis, but simply to present a few devices which I have resorted to in the cultivation of anaërobic bacteria, more particularly the tetanus bacillus, for the production of a satisfactory tetanus toxin. The tetanus bacillus, like the bacillus of diphtheria, produces a toxin which diffuses into the culture fluid. When the bacteria have been removed by filtration the filtrate is still highly toxic and may be employed to immunize horses destined to yield antitoxin. The cultivation of the tetanus bacillus in fluids on a large scale for this purpose demanded apparatus simple and easily manipulated, to reduce as far as possible the danger associated with the manipulation. The removal of the air by aspiration, and the substitution of hydrogen, is a procedure requiring much time, and, especially with fluid cultures, is likely to lead to unsuspected contamination with miscellaneous bacteria.

The development of anaërobes in the ordinary fermentation tube was known to me for some years, and I set about

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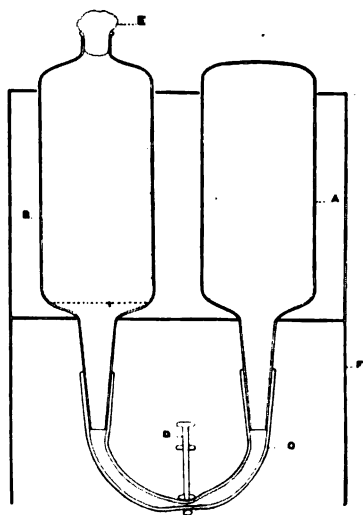[1] Centralblatt f. Bakteriologie, xvii, s. 168.
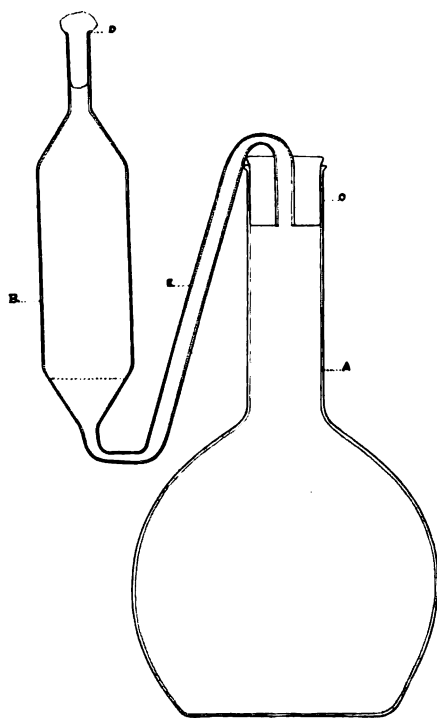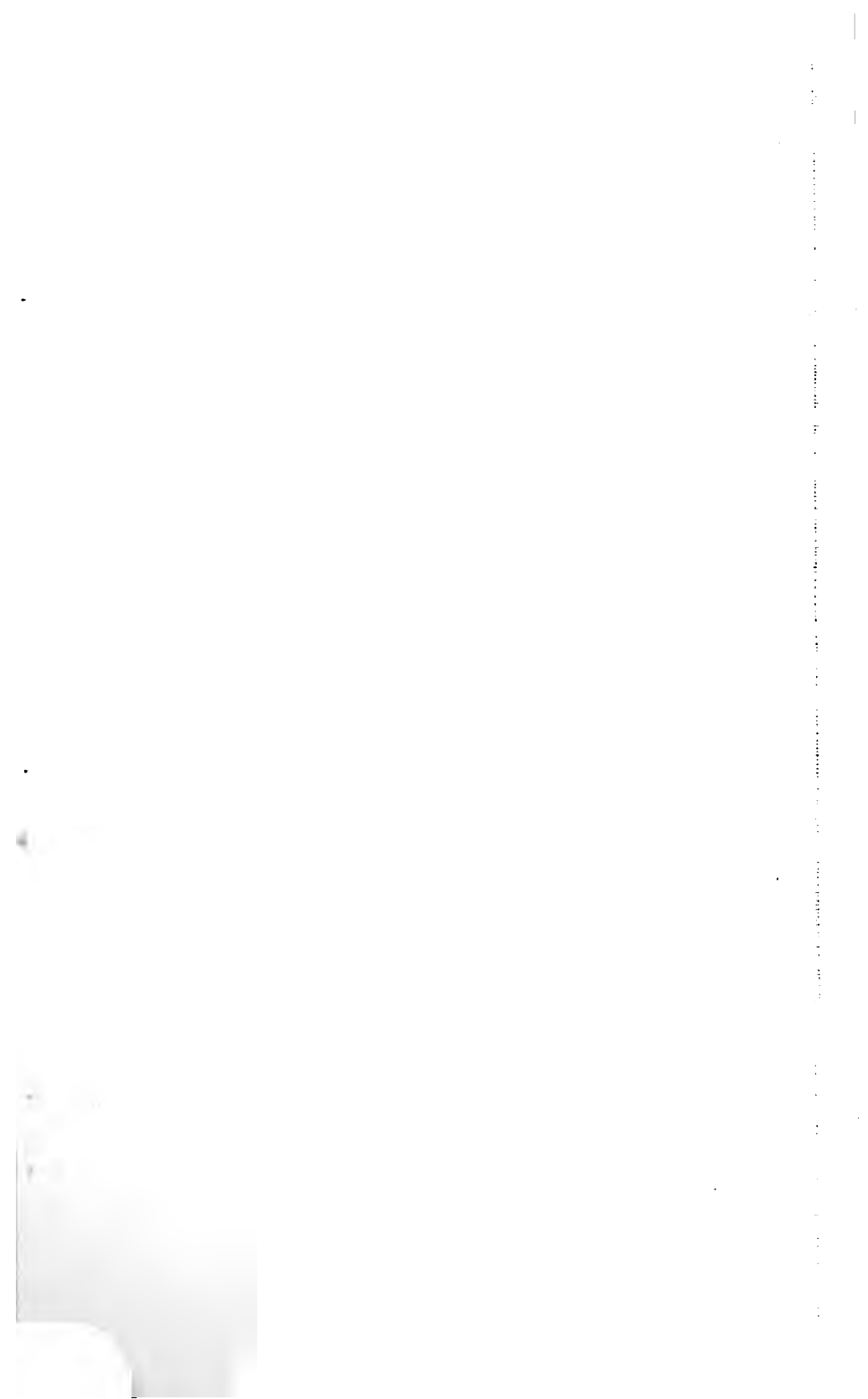
PLATE II.

FIG. 1.

FIG. 2.

devising culture flasks which would imitate this. The fermentation tube is, however, not fully satisfactory, because the contact of the fluid with the air is a little too free for some anaërobes. The multiplication does not go on at times as freely as is desirable unless the culture fluid is thoroughly steamed before inoculation. The bacilli may degenerate and fail to sporulate.

The culture apparatus shown in Figure 1 was exhibited to this Society in 1897, but no description published. It consists of two bulbs, *a* and *b*, which are of nearly equal capacity, and which may be made as large as desired. The two are connected by means of a heavy rubber tube *c*. A clamp *d* is of use at times to restrict communication between *a* and *b* to a minimum. The bouillon occupies the whole of *a*, the connecting tube, and all below the dotted line in *b*. It is inoculated by transferring material containing the bacillus or its spores with platinum loop or pipette through the cotton-plugged opening *e*. The growth travels down into the bulb *a* within twenty-four hours. Bulb *a* may be constructed with an upper opening to facilitate filling and cleansing. Such opening must be kept tightly stoppered and the rubber stopper wired down so that air may be absolutely excluded. It is evident that the bulb *b* is needed to receive the fluid almost wholly driven out of *a* by steam forming in it during sterilization, as well as the fluid crowded out of *a* by gases which are quite regularly produced by anaërobes in media containing dextrose and some other sugars. The apparatus is best manipulated in a rack of tin *f*, easily made for it.

For more than a year past I have replaced the culture apparatus just described by a flask in some respects more, in others less, satisfactory. This is shown in Figure 2. It consists of a stout litre flask *a* into which is fitted, with the aid of a rubber stopper *c*, a 100 c.c. pipette *b*, with the lower portion *e* bent as shown in the figure [1] and the upper shortened and provided with a cotton plug *d*. The bouillon fills the

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[1] The angle formed by the bulb *b* and the ascending tube *e* must be at least as great as drawn in the figure. Should any air bubbles remain in the upper bend of *e* after sterilization they can be tilted out without wetting the cotton plug *d*. If the angle is too small the fluid will run out at *d* when the flask is inclined to remove such bubbles.

flask completely and extends down the narrow tube to the dotted line in the bulb. It is inoculated through the opening *d*. The growth proceeds unaided along the narrow tube and reaches the flask in twenty-four to thirty-six hours.

These two flasks permit a rich growth of the tetanus bacillus. In about five or six days the multiplication ceases. With the culture in my hands the unfiltered bouillon is fatal to a guinea-pig in doses of .00005 c.c. to .0002 c.c.[1]

The second flask has one disadvantage which necessitates some additional work. It cannot be autoclaved when filled, because the sudden ebullition throws out some of the fluid. In the Arnold sterilizer this does not occur and no difficulty is experienced. To obviate the loss of fluid in the autoclave the following procedure has been adopted: The flask itself is not entirely filled, but as much as is needed for this purpose is autoclaved with it in an ordinary flask. During the sterilization the bulb *b* with attached stopper either rests lightly in the flask or may be placed separately into the autoclave. After the sterilization the flask is filled up with the extra fluid, and the stopper forced in and tied down with twine. This can be done without contaminating the contents. In any case a final steaming in the Arnold sterilizer proves successful. If the flask is simply steamed it must be carefully watched, as the undestroyed spores of anaërobes may germinate after the third or even the fourth steaming. It is best to steam the flask in the late afternoon and place it into the incubator. Early next morning the flask should be steamed again and kept during the night in the incubator. During the next day the third steaming should take place. Finally, after an incubation of forty-eight hours, the flask is steamed for the last time. Even with the most careful watching, flasks may suddenly become turbid over night. In all cases the offending organism is an anaërobic bacillus. The difficulty with which the spores of these bacilli germinate is only equalled by the rapidity with which they multiply when once started. It is obvious from what has been stated that the

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[1] The bouillon here referred to is the ordinary peptone bouillon prepared from fresh beef. Sugar should not be added unless the specific action on different sugars is to be studied. The beef contains enough dextrose to promote multiplication in these flasks.

autoclave is to be preferred in the sterilization of not only this flask, but of culture fluids in general.[1]

A third device which has rendered valuable aid in continuing the cultivation of anaërobes is the following: A guinea-pig, rabbit, pigeon, or other small animal is killed with chloroform, and pieces of the internal organs, more particularly the spleen, liver, and kidneys, as large as peas or beans, are torn quickly from the organs with sterile forceps and introduced into fermentation tubes containing ordinary peptone bouillon. The tissue should be eventually forced into the closed branch of the tube with a stout platinum wire. A series of such tubes are prepared at one time and placed in the incubator for several days to reveal any contaminating bacteria from the air or the introduced tissue. Tubes provided in this way with bits of sterile tissues furnish most favorable conditions for the cultivation of anaërobes. They may be kept indefinitely and when partially dried out, refilled with sterile water. Anaërobes will still multiply freely in them, though they have not been reboiled. In fact, boiling would cloud the bouillon by coagulating the albumen from the introduced tissue. I have obtained in these tubes most copious spore-production of the tetanus bacillus. It is frequently desirable to have on hand fluid cultures of this and other anaërobic bacilli for the study of morphological and physiological characters. The simple method suggested enables us to obtain them at any time as readily as the commonly employed but much less accessible and less convenient deep-tube cultures in solid media.

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[1] See also my paper on this subject in the Journal of Experimental Medicine, iii (1898), p. 647.

PRELIMINARY REPORT ON THE DIPLOCOCCUS OF SCARLET
FEVER (CLASS).

CALVIN G. PAGE.

(*From the Bacteriological Laboratory of the Harvard Medical School.*)

During the past month I have made cultures from eight
more cases of scarlet fever. In five of these I found a large
diplococcus resembling that recently described by Dr. Class,
of Chicago. I am confident that I saw a similar large
diplococcus in a number of the primary cultures from the
twenty-four cases, although I have no slides which show it ex-
cept one from a bouillon culture from the skin of case 24,
dated March 7, 1899.

A loop from this culture was planted on a hydrocele serum
plate. After two days in the incubator, plate showed abun-
dant growth of several species, but as preparations showed
only mixed cocci — no streptococci — I left it on the desk.
After a few days I noticed a moist growth extending out
from the lines of inoculation, which continued to spread until
the plate dried.

On May 19 I finished making some agar-agar containing
garden earth, as suggested by Dr. Class, and planted the first
tube from the spreading growth on this plate. There was an
abundant growth, very moist and sticky. Preparations from
it showed a large diplococcus, which seemed to resemble the
one described by Dr. Class. Apparently the culture grew
better at the room temperature than in the incubator.

Then I took cultures from four cases at the Boston City
Hospital and also examined one throat culture from Brookline
Board of Health. These all made good growth in incubator.
Preparations from two cases showed a large diplococcus, but I
could not isolate it because the other organisms grew so fast.
I found that I had neglected to add 6% glycerine to the loam
agar. So, after correcting the mistake, I took cultures from
four more cases, throat or desquamated skin, and left the tubes
at the temperature of the laboratory (85° F.). Preparations
from three of the four cases showed large diplococci, two
from the skin and one from the throat. I have succeeded

in isolating the large diplococcus by successive transfers from one of these cases (31). The acidity of the loam agar (+1.%) is probably not the same as that of the agar made by Dr. Class. He does not give the acidity of his medium, but states that other organisms will not grow well on it. The agar I made will grow streptococcus and other organisms at room temperature.
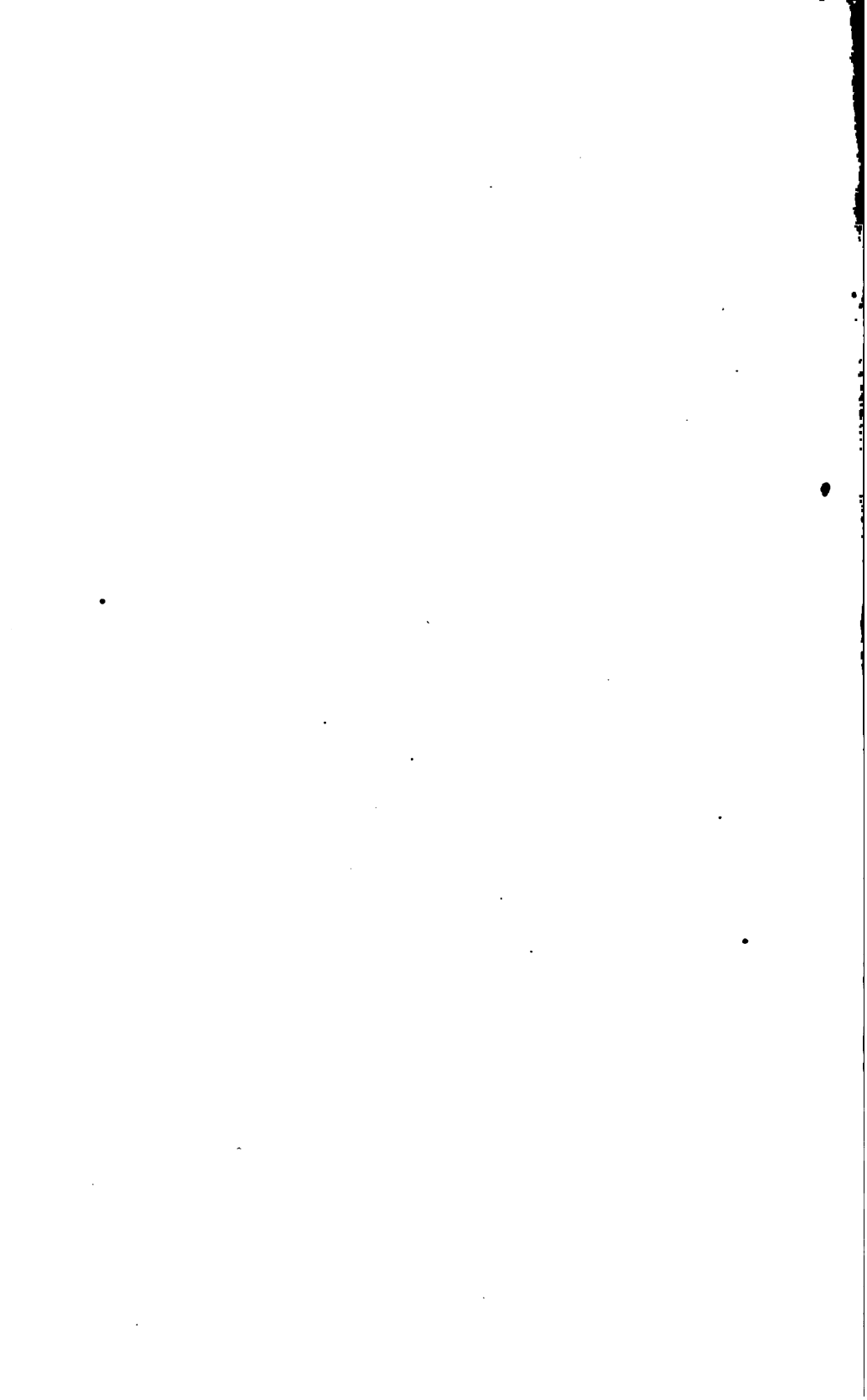
By inoculating a pure culture of his large diplococcus into the ear vein of young swine Dr. Class produced a disease closely resembling scarlet fever, and recovered the organism from the blood and desquamated skin of the animals.

The isolation of the large diplococcus presents some difficulties, inasmuch as the glutinous substance holds the cocci together so that it is hard to be sure of colonies from a single coccus. Also other organisms grow through the glutinous substance, so that the two are most intimately united. Furthermore, the diplococcus shows great variability in size and shape, so that much study will be needed to determine its behavior on different media. There is, too, another coccus from the skin which might be called a large diplococcus.

If the organism described by Dr. Class proves to be the cause of scarlet fever numberless problems suggest themselves to be worked out. An important one, I think, will be the effect of increasing percentages of carbolic acid in the culture media upon the virulence of the organism, to see if there is any rational basis for treatment of the disease by large doses of carbolic acid (5 to 30 grains per day in five doses freely diluted), as recommended by Dr. A. Wigglesworth, of Liverpool.

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SPECIAL NOTICE.

The Journal will be published *immediately* after the meetings of the Society, and will contain authors' abstracts of the papers presented, when these papers are not given in full.

By general consent of the Heads of Departments it will contain full abstracts of experimental work carried on in the following institutions: the Medical School of Harvard University, the Experiment Laboratories of the Massachusetts General and the Boston City Hospitals, the Physiological and Biological Departments of the Massachusetts Institute of Technology, Clark University, and the Anatomical Laboratory of Brown University.

Papers and abstracts of papers upon subjects connected with the Medical Sciences will be welcomed from persons not members of the Society, and if approved by the Council will be presented at the meetings, and will be given a place in the Journal.

When desired, the insertion of papers, if in abstract, will be accompanied by a note indicating the place where they may be found in full. Fifty reprints will be furnished free to authors if the desire for them be expressed on the manuscript.

Subscribers to the Journal are invited to attend the meetings of the Society; the next will be held on October 17, at the Harvard Medical School, at 8 P.M.
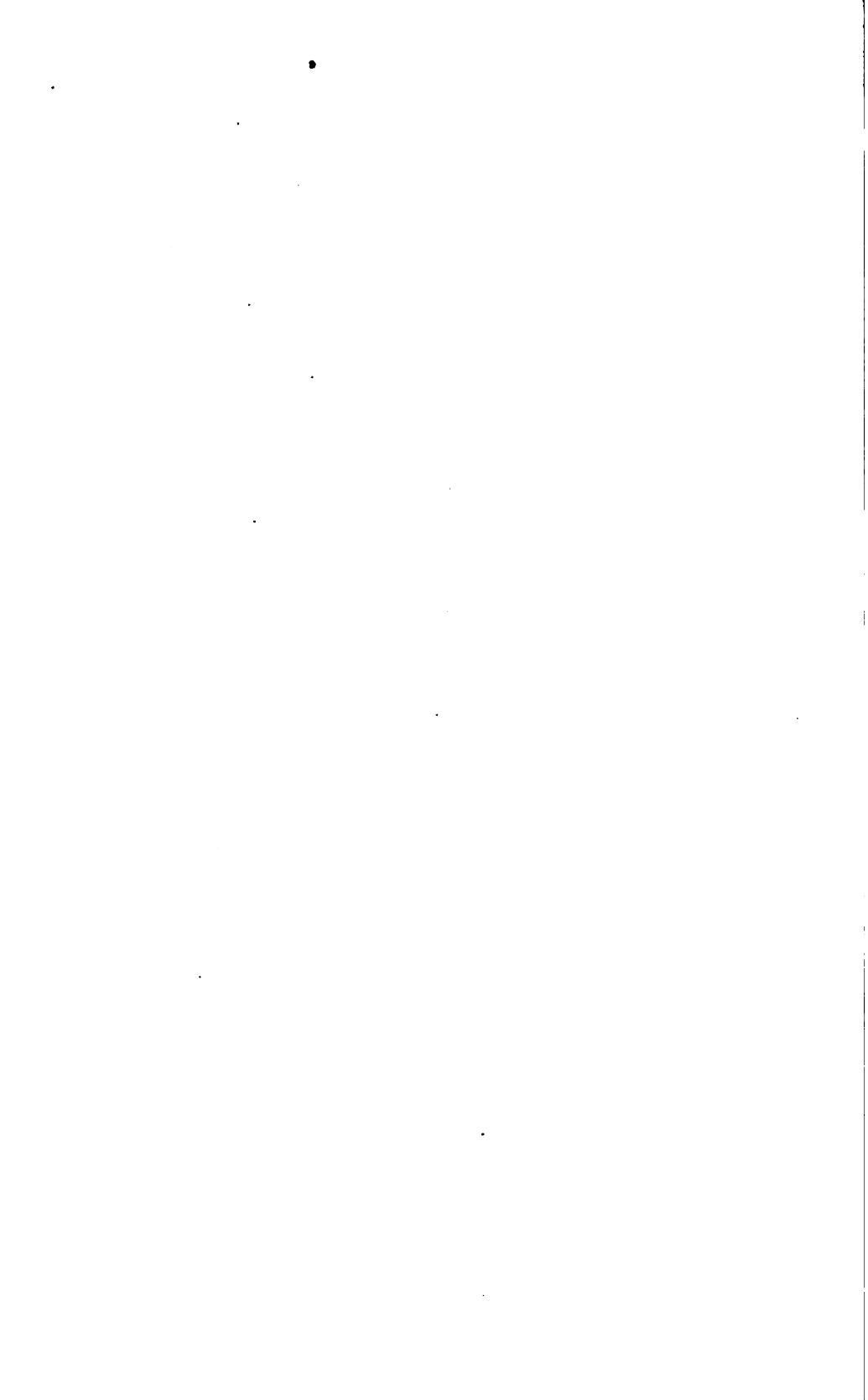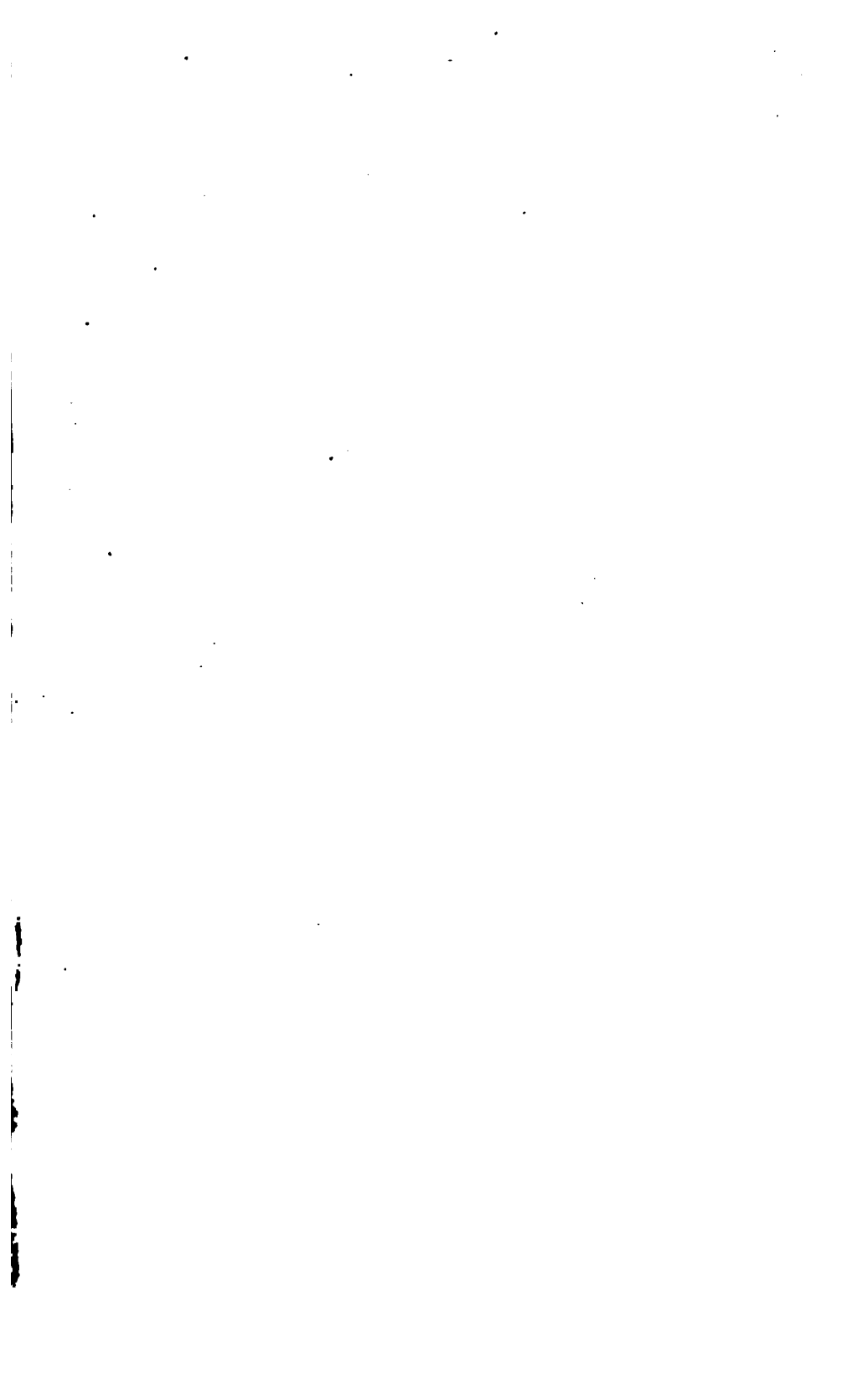
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